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Le document présente le nouveau programme d'études en sciences physiques pour le deuxième cycle du secondaire. Ce programme a été conçu en fonction des découvertes récentes dans les domaines de la théorie de l'éducation et de l'épistémologie. Il est centré sur l'intégration de la méthode expérimentale et de l'induction. La matière inclut l'organisation des concepts reliés à la matière et l'énergie, le concept de modèle et la nature de la science elle-même. En même temps que l'acquisition de connaissances et le développement d'habiletés, le nouveau programme vise le développement d'une attitude scientifique chez l'élève, indispensable à l'apprentissage des sciences à des niveaux plus élevés.

Type de document

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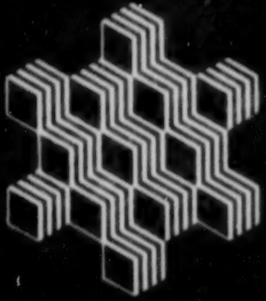

PHYSICAL SCIENCES 416-436

THE DISCOVERY OF MATTER AND ENERGY

Québec

90-70299

Secondary School Curriculum

PHYSICAL SCIENCES 416-436

THE DISCOVERY OF MATTER AND ENERGY

Direction générale des programmes
Direction de la formation générale

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Claude Ryan

Claude Ryan
Minister of Education

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FOREWORD

This document is the program-guide for the Physical Sciences program intended for all Secondary IV students. The program consists of the two following paths:

- Physical Sciences 416, the regular path for students who do not plan on opting for the college-level Natural Sciences concentration or for a vocational program with physics and chemistry prerequisites.

- Physical Sciences 436, the enriched path for students who are capable of covering this material or who intend to take the Secondary V physics and/or chemistry courses.

Physical sciences teachers (chemistry and physics), directors of educational services, teaching co-ordinators, and educational consultants specializing in the field of natural sciences should refer to this document when preparing and conducting activities related to the teaching of physical sciences in Secondary IV.

This program was developed by the Direction de la formation générale des programmes in collaboration with educational consultants and teachers. Each path includes compulsory content and enrichment activities. School boards are responsible for setting up an adequate educational and material framework so that students can attain all compulsory objectives in a manner consistent with the orientations emphasized in this program. Information to this effect is provided in Part 7. Teachers, with the help of educational consultants, are responsible for developing specific enrichment activities for those students who can go beyond the compulsory material.

Each module includes a series of learning activities, teaching strategies, and other information that can help teachers prepare their courses and evaluate student learning. This pedagogical information is usually found in a curriculum guide. All of these elements are contained in this program-guide.

1. INTRODUCTION

1.1 Background

A comprehensive survey of a large number of educators conducted by the ministère de l'Éducation in 1977 revealed, among other things, that programs no longer met the needs of students and of Québec society. As a result, the ministère began to revise all elementary- and secondary-level programs in 1978.

A **Plan of Action**[1] was published in 1979. It redefined the objectives of Québec education and suggested ways of dealing with certain problems in the educational community. The **Plan of Action** also outlined compulsory and optional programs for each year of schooling.

In 1981, the ministère published the **Regulation Respecting the Basis of Secondary School Organization**[2] to give the educational provisions of the **Plan of Action** the force of law. The Basic School Regulations were revised in 1986.

Chemistry and physics courses have become a more important part of secondary education since the publication of the **Green Paper**. According to the Regulation, Secondary IV students must pass a six-credit science course covering the basic principles of chemistry and physics to obtain a Secondary School Diploma.

1.2 Needs Analysis

The Direction des programmes decided to consult science educators in 1986 because it felt that the science curriculum, and especially the chemistry and physics programs, had undergone substantial change. To improve the decision-making process normally associated with the development of new chemistry and physics programs for Secondary IV and V, the Direction decided to do a formal needs analysis based on a questionnaire administered to science educators.[3] The purpose of the needs analysis was to determine the orientations and content of the new programs, to establish priorities, and to ensure that secondary-level courses were brought into line with those offered in CEGEP.

---

[1] Québec, ministère de l'Éducation, **The Schools of Québec: Policy Statement and Plan of Action**, Code 49-1070A (Québec: ministère de l'Éducation, 1979).

[2] Québec, ministère de l'Éducation, Direction générale du développement pédagogique, **Regulation Respecting the Basis of Secondary School Organization**, 1983. Hereafter referred to as the Basic School Regulations. (This is the English translation of the Régime pédagogique published in 1981).

The needs analysis was followed by the publication of the document **New Physical Science Programs: Key Issues and Rationale**,[4] which describes the current situation regarding physics and chemistry programs and specifies the measures that should be taken to improve the situation. This document served as a basis for further consultation with the various educators and officials involved with this matter.

In addition, many studies concerning science education have been published over the last ten years. Included among these are the Rapport Evalensci, the analysis of the ASOPE, the Projet de l'orientation de l'éducation scientifique prepared by the Direction générale du développement pédagogique, the reports of the Association des professeurs de sciences du Québec, various studies on science education and scientific knowledge such as those written by Jacques Désautels, Pierre-Léon Trempe and their associates, and the advisory documents published by the Conseil supérieur de l'Éducation. The team that developed the foundations, orientations, and learning content for this program based their work on these reports and on comparative studies of the teaching time and content of physics and chemistry courses in Québec and elsewhere.

1.2.1 CURRENT SITUATION

According to the many people who were asked to comment on it, the information document published in 1986 provided a relatively accurate analysis of the current situation regarding physics and chemistry programs. This section is based on that analysis.

---

[3] Québec, ministère de l'Éducation, Direction de la formation générale, **Analyse des besoins relative aux programmes de chimie et de physique de 4^e et 5^e secondaire.** Rapport de la 1^{re} étape, juin 1986. (Québec: ministère de l'Éducation, 1986).

[4] Québec, ministère de l'Éducation, Direction de la formation générale, **New Physical Science Programs: Key Issues and Rationale**, Code 72-0004 (Québec: ministère de l'Éducation, 1987). Hereafter referred to as the information document.

Since the introduction of American methods for teaching chemistry and physics (CHEM STUDY, HPP, PSSC), which drew great praise from most teachers, the foundations, goals and values of chemistry and physics education have seldom been questioned by teachers or even the Ministère. These methods were used mainly with gifted or relatively gifted students who were older than today's students, in order to provide them with the prerequisites for university science programs.

These methods are no longer suitable. Today's students are younger, and less time is devoted to chemistry and physics courses. Because of the amount of material that must be covered, teachers are forced to rely on class lectures and to neglect laboratory work which, in any case, simply involves confirming what was learned in the classroom. Thus, current practices do not really reflect the philosophy behind these American methods. As a result, students find it difficult to assimilate the basic concepts of science and develop the skills and attitudes associated with the scientific approach. In addition, current teaching methods are dogmatic and disregard the social and technological aspects of science.

Although programs based on current methods do have some merit given that they have produced a generation of topflight scientists, modern pedagogical and epistemological research has cast doubt on their effectiveness and validity. For the most part, these courses are overly concerned with conceptualization and promote a dogmatic belief in the superiority of scientific knowledge. They focus on descriptive science.

This approach to teaching chemistry and physics does not seem to provide young people with the basic scientific knowledge they need to become informed citizens and to contribute to the development of their society. Young people know little about science in Québec and its relationship to technology and society.

Teachers often present science as a set of absolute objective truths. Students memorize and blindly apply mathematical formulas. Thus, they are ill-equipped to understand and take an active part in the natural and technological world in which they live. They feel that the world of science and technology is inaccessible, perplexing or irrelevant. They have no opinions regarding current scientific problems and cannot recognize spurious assertions that masquerade as scientific fact.

Methods of evaluation reflect this type of teaching, but some may feel that the opposite is also true, namely that instructional approaches are conditioned by the method of evaluation. Science teaching is still geared to preparing students for exams.

The underlying problem is that scientism has become the dominant view of science. Science authorities unwittingly give the impression that scientific knowledge is superior to all other forms of knowledge. Consequently, society is conditioned to believe that scientific results are unbiased, rarely inaccurate, distinct from their practical applications, and beyond any moral or ideological concerns. In this context, it is easy to accept the notion that scientists are concerned with the advancement of scientific knowledge for its own sake.

1.2.2 DESIRED SITUATION

Physics and chemistry programs must be revamped otherwise young people, the citizens of tomorrow, are likely to be ill-prepared for a society in which science and technology play a dominant role. The time seems right for change, since scientific issues have a much greater impact on everyday life. Programs should focus on skills, related content, and attitudes, providing young men and women with the scientific knowledge they will need to become socially responsible citizens and enter more advanced science programs. It is important to breathe new life into these programs so that students develop an interest in those subjects.

Physics and chemistry programs should help students develop scientific and technological abilities for a world in which these skills are synonymous with development. These disciplines have had a significant effect on different aspects of our existence, as evidenced by the role they have played in the fight against acid precipitation, in the development of energy sources, recycling techniques, and superconductive materials, and in the use of isotopes. Thus, there is no doubt that they should become part of a student's basic education, since this will be the last time that most students will ever study these subjects.

It is also important to help students acquire basic scientific knowledge so that they can better understand the issues arising from the interrelationship of science, technology, society and the environment. Through the study of chemical and physical phenomena, students should become familiar with the practical implications of scientific work.

If students are afforded the opportunity to develop genuine "scientific" attitudes and the skills related to scientific inquiry, they will not only acquire a greater understanding of various types of physical phenomena in their environment, but also be able to live in greater harmony with that environment. The teacher should encourage students to develop a better understanding of their place in the world and to question a whole range of prejudices with a view to making them aware of the importance of environmental protection and resource conservation.

One program alone cannot change everything. All educators, and especially teachers who deal directly with young people, should take a less scientistic approach to science and guide students through the learning process. In addition, educational authorities will have to ensure that schools have a trained staff, proper facilities and equipment, the necessary technical support staff, as well as teaching materials and evaluation instruments that reflect the new orientations of the program.

1.3 Priorities

What emerges from the formal needs analysis, and the aforementioned studies, reports and advisory documents is the need for a comprehensive revision of all secondary-level chemistry and physics programs. Future programs should be based on a different set of orientations so that students can acquire the scientific knowledge they will need to function in a technological society and to study chemistry and physics at a more advanced level.

Thus, the new Secondary IV Physical Sciences program should:

- be compulsory for all students
- interest them
- reflect the interests and needs of both boys and girls
- be geared to their level of intellectual development
- enable them to acquire practical knowledge that is essential to all citizens
- give them the opportunity to conduct experiments so they can learn how to think scientifically
- provide students with information on the environment and environmental issues
- stimulate interest in science
- stimulate interest in research
- prepare students for more advanced science programs

1.4 Relationship with Other Science Programs

In this Physical Sciences program, students continue to explore various phenomena introduced at the elementary level and studied in greater depth during the first three years of secondary school. They now have the opportunity to apply this knowledge to the study of chemical and physical phenomena.

Students were gradually introduced to the inductive experimental approach in previous elementary- and secondary-level science courses. As a result, they have undoubtedly begun to learn how to think critically and logically. This course should encourage students to continue to develop skills and attitudes associated with scientific inquiry.

Like earlier compulsory science programs and optional programs such as General Biology and Geology, this course examines the way in which science, technology, and society are interrelated, and does so in greater detail. Like these courses, it is also concerned with informing students about environmental matters.

2. VALUES, FOUNDATIONS, AND ORIENTATIONS

2.1 Values

Part I provided a description of the type of person that should emerge from this new program. The aim is to stimulate the students' interest in science and technology, to make them aware of the relationships between science, technology, Canadian culture, and society, and to help them become informed and socially responsible citizens.

This concept of a socially responsible person underlies the values promoted in this program. These are the values that Secondary IV students should strive to adopt as they study chemical and physical phenomena. These values, which are listed below, can be regarded as the different facets of a "scientific education."

- Intellectual Values:
  - methodical and rigorous work habits
  - a constant search for the truth
  - an interest in research

- Social and Cultural Values:
  - an open-minded view of nature, science, and technology
  - a concern for providing boys and girls with equal opportunities in the field of science
  - international cooperation in dealing with today's major problems
  - team spirit
  - a concern for correct language

- Moral Values:
  - a realistic view of science
  - respect for life and for the environment
  - individual effort and self-discipline
  - autonomy
  - a sense of responsibility
  - a concern for health and safety

The knowledge, skills and attitudes that students will acquire in this program are indissociable and reflect the values listed above.

2.2 Foundations

As students and as teachers, educators have become familiar with science programs focusing on a hierarchy of concepts and learning content and on methods of inquiry that rationalized the process which led to the development of scientific laws and theories. The needs analysis and the studies mentioned in Part I indicate that teaching methods for chemistry and physics programs must be modified if students are to acquire the basic scientific knowledge they will need to function in a technological society and to study science at a more advanced level.

The authors have tried to design a program in accordance with recent findings in the fields of the educational theory and epistemology even though these elements are difficult to incorporate into a program that consists of learning objectives. The program is based on the following sociological, pedagogical, and epistemological principles.

2.2.1 SOCIOLOGICAL PRINCIPLES

In this age of science and technology, it is essential that everyone become familiar with the physical sciences. It would be a serious mistake to regard these disciplines as fields that concern only a certain elite. All students should become familiar with key scientific and technological concepts so that they can understand how science and technology affect individuals, society, the economy, and political life.

Science programs should therefore deal with social concerns. Science affects economic, social, and cultural development. Since the students are members of this society, it is important to help them become informed participants in the social debate on science, technology and society. It is also important to make them aware of environmental issues so that they learn to show respect for the environment on a daily basis.

A program that focuses on social concerns and on the relationships between science, technology, and society should also cover certain aspects of the history of science. Students should learn about the political, economic, technological, and ideological factors that have influenced the development of scientific knowledge. It is important that they also become aware of the contributions of women as well as men.

2.2.2 PEDAGOGICAL PRINCIPLES

Over the last few decades, there has been a great deal of research in the fields of science education and psychology. It is generally agreed that learning is an active process. Thus, it is important to allow students to take an active part in their own education by developing learning situations geared to their intellectual abilities and interests and related to their environment. In this case, teaching methods should focus on the person and not the learning content.

Recent studies seem to show that only a small percentage of students reach the formal operational stage by the end of high school. These studies may explain why students find that purely theoretical knowledge is difficult to assimilate or of little interest to them.

Thus, it is important to make a clear distinction between what the students know and do not know. The teacher should always explain abstract concepts in terms of the knowledge, skills, attitudes or values that the students have already acquired. If they find certain ideas difficult to grasp, the teacher should make a special effort to help them discover examples of these phenomena in their environment. Concrete experiments should also be used.

In addition, when introducing a topic, it is important to identify commonly held beliefs that may underlie the students' initial explanation or representation of a concept or phenomenon. These beliefs are used as the basis for helping the students to "construct" the learning content. If necessary, demonstrations, simulations or other appropriate techniques can be used to illustrate certain points.

Students often indicate that they are interested in a subject by asking questions. If they are not sufficiently stimulated to ask questions, it will be difficult to motivate them to learn anything of substance. To facilitate learning, the teacher should therefore make a point of choosing an instructional approach that maximizes the possibility of eliciting relevant questions that can then be examined in greater detail.

2.2.3 EPISTEMOLOGICAL PRINCIPLES

Modern epistemological studies have shown that scientific knowledge results from human intellectual activity, and is not necessarily an absolute reflection of reality, as society has often been led to believe. Because scientific knowledge is the product of human actions, the process by which it is acquired is characterized by dead ends, mistakes, gaps, setbacks, and successes. This process does not always lead to the truth. While scientific knowledge is developed to deal with the problems of the moment, it is also deeply rooted in the past and is "constructed." Thus, it is important to show how the subject matter is related to history, social concerns, technology, and environmental issues.

It is also important to help young people discover the validity and limitations of the experimental approach by getting them to perform experiments like real scientists. In this way, they will appreciate scientific research and be able to assess the relative merit of various theories.

2.3 Subjects of Study and Integrating Themes

This Physical Sciences program is centred on the following integrating themes:

. "scientific" work methods, in particular the experimental method
. "scientific" ways of thinking, in particular the inductive method

The subjects of study include:

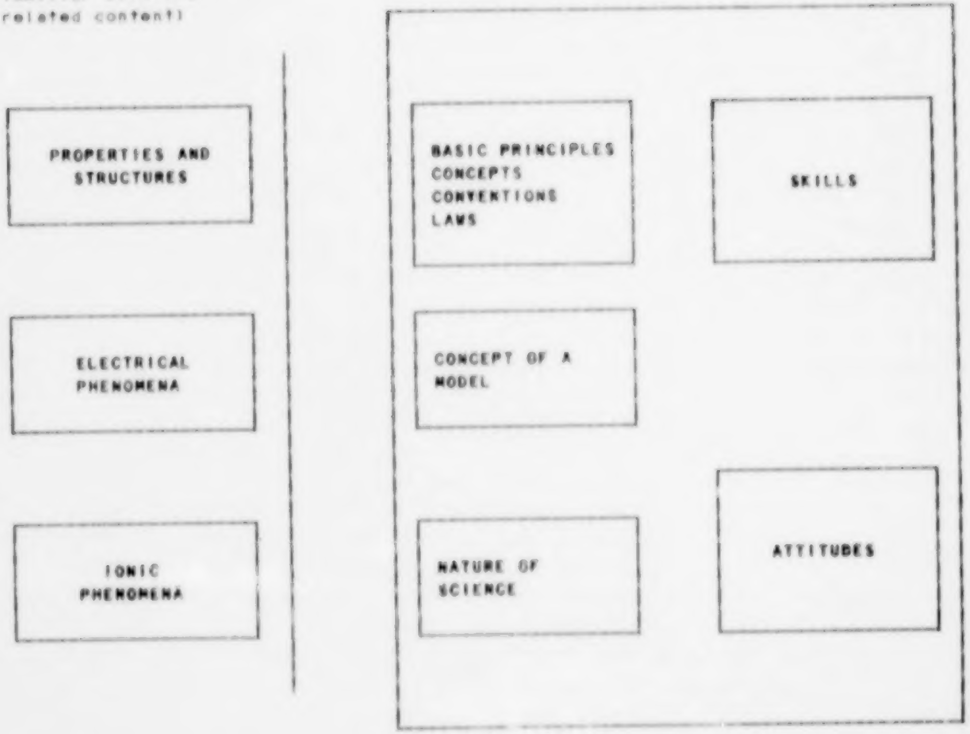
. a more in-depth examination of the organization of concepts related to matter and energy
. the concept of a model
. the nature of science itself

The students should "construct" the subjects of study by doing laboratory work and by exploring their environment, the interrelationships of science, technology and society, and the history of science.

TOPICS

(Vehicle through which students become familiar with the related content)

SUBJECTS OF STUDY


PROPERTIES AND STRUCTURES
ELECTRICAL PHENOMENA
IONIC PHENOMENA
BASIC PRINCIPLES
CONCEPTS
CONVENTIONS
LAWS
SKILLS
CONCEPT OF A MODEL
NATURE OF SCIENCE
ATTITUDES

2.4 Learning Approach

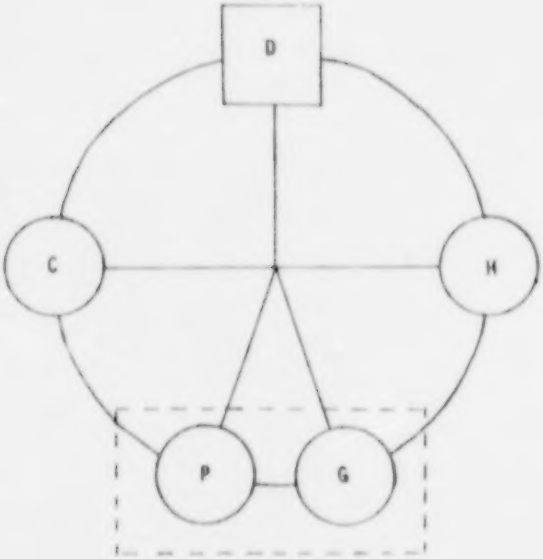
The goal is to develop the type of student who reflects the values promoted in this program. This program has as its foundation a "constructivist view" of the acquisition of knowledge. According to this philosophy, science is the result of intellectual efforts to acquire knowledge and understanding of phenomena in the environment, based on previously acquired knowledge. The aim is to encourage students to "construct" their own knowledge through their own investigations. In essence, they become the architects of their own education.

To achieve this goal, it is important that the material in this program be covered using a problem-solving approach. Based on their experiences and the knowledge they have acquired, the students expand their own knowledge and continue to develop skills and attitudes that will help them deal with different life situations.

The various topics should be presented as a series of problems in which students learn how to link familiar concepts with new experiences and deal with information that may contradict their own intuitive ideas about chemical and physical phenomena. After discussing the problem among themselves and defining it in terms of what they already know, students try to find a solution using a variety of investigative techniques. They analyze their results to see whether they are at variance with their predictions. This may result in their taking a radically different view of the concept or phenomenon they have studied. The knowledge, skills, and attitudes they acquire through this exercise can help them deal with other similar problems in or outside the classroom. Because students are actively involved in finding their own solutions based on what they already know, they are "constructing" knowledge instead of passively assimilating facts. Consequently, what they learn will likely be more meaningful than the information they would receive in a more passive learning situation.

The following diagram illustrates the approach emphasized in this program. Each step is explained in detail. As with the acquisition of knowledge, this process is not necessarily linear, continuous, cumulative, or free of error and failure, especially since the students' thought processes are not always consistent with those required for scientific inquiry.

DIAGRAM OF PROBLEM-SOLVING APPROACH



Verification = Analysis

Legend:

D: Defining the Problem
H: Formulating a Hypothesis
G: Gathering the Data
P: Processing the Data
C: Conclusion

- DEFINING THE PROBLEM:	After examining their observations and measurements, doing experiments and readings, and working with audio-visual materials, students may have a variety of questions or, in some cases, may recognize that they are faced with a genuine problem-solving situation. A cognitive gap occurs when students are confronted with this type of situation. They will show interest in solving the problem if they feel they can benefit from this exercise. Students begin by trying to define the problem as precisely as possible.
- FORMULATING HYPOTHESES:	Students react to the situation by proposing one or more solutions which they feel are plausible. These solutions may be based on intuition, logical reasoning or a detailed explanation.
- GATHERING THE DATA:	Students look for and examine the information or source materials related to the problem. This data can be obtained through observations, measurements, experiments, investigations, documentary research or other relevant techniques.
- PROCESSING THE DATA:	Students organize, classify and compare the data and interpret it to see if their hypothesis(es) are confirmed. They relate the information to the goal they have set for themselves.
- CONCLUSION:	After evaluating their hypothesis(es), the students present the results by writing a report, developing a model, formulating a law or a theory or using other appropriate methods. They review the entire learning situation and examine their approach and the results. They will be able to apply the knowledge they have acquired to similar learning situations.

The preceding analysis is an attempt to describe what happens when students learn through problem solving. They gradually become familiar with a work method that does not always lead to the correct answer, but that enables them to "construct" knowledge, skills and attitudes.

This method is often called scientific. Although it has many definitions, it is generally agreed that it is a problem-solving technique whereby scientists test hypotheses until they find one that is consistent with known facts.

2.5 Teacher's Role

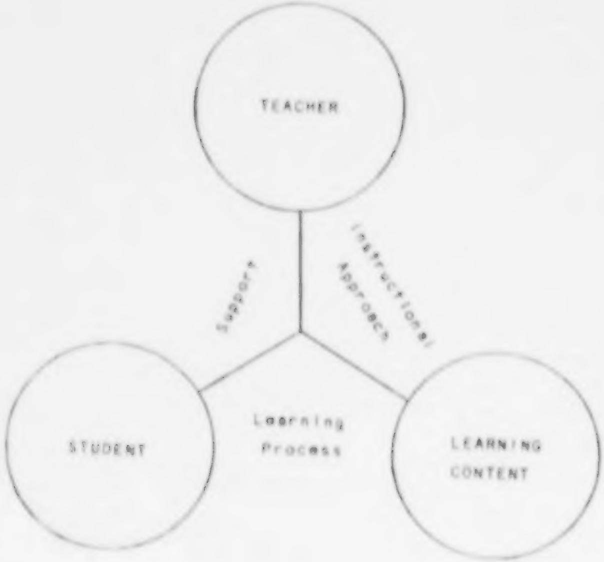
Since learning is defined as a dynamic process in which the students "construct" their own knowledge, the teacher's role is to guide the students through the learning process. The teacher should adapt to the students, and not vice versa. He or she encourages the students to develop their talents by choosing the most appropriate strategies and learning activities. Teaching is geared to the student's potential and is by no means based on a single approach. The challenge facing teachers is to use instructional approaches and learning situations that help the students understand physics and chemistry and that stimulate their interest in these subjects.

Science education would be more meaningful and fascinating if secondary-level programs dealt with the students' environment and with technology, since it is closely related to science. While it is important to help students understand concepts, models and laws, this goal can best be achieved by relating the theory to natural and man-made objects in the environment.

To help students learn, the teacher should devise and organize a variety of activities that are concrete, adapted to the students' abilities and interests, and directly related to their life experiences. In addition, these activities should reflect a concern for health and safety and for environmental protection. Some may feel that the teacher's role has been profoundly changed. Even if teachers know the answer or the right approach to a problem, they must prepare learning situations for the students, guide them through the learning process, support them, and help them take stock of what they have done and of what they have learned. The teacher can be regarded as a catalyst in this new approach to physical science education.

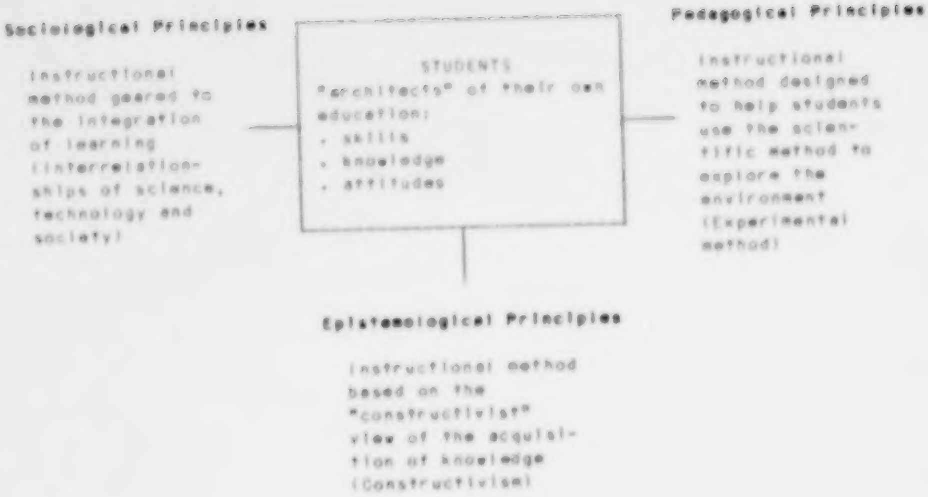
Thus, this program is based on an interactive learning approach. The teacher provides students with the opportunity to experience the real world of science. Students are encouraged to work together and with the teacher and to discover how science is related to history, technology, social concerns, and environmental issues.

TEACHER'S ROLE


TEACHER
Support
Instructional Approach
STUDENT
Learning Process
LEARNING CONTENT

2.6 Guiding Principles

The three guiding principles summarized in the following diagram reflect the results of the needs analysis, and the foundations and orientations outlined in previous sections.



Sociological Principles

Instructional method geared to the integration of learning (interrelationships of science, technology and society)

STUDENTS

"architects" of their own education:

- skills
- knowledge
- attitudes

Pedagogical Principles

Instructional method designed to help students use the scientific method to explore the environment (Experimental method)

Epistemological Principles

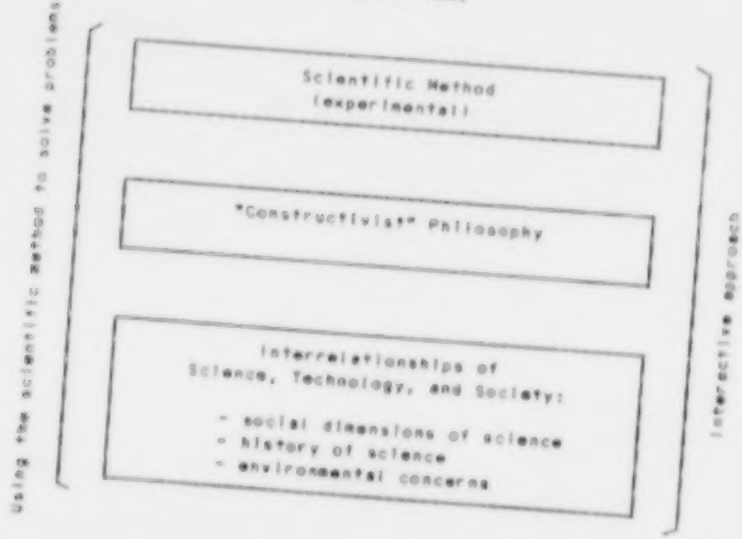
Instructional method based on the "constructivist" view of the acquisition of knowledge (Constructivism)

2.7 Summary of the Orientations of the Program

In this program, a great deal of emphasis is placed on the experimental method and on laboratory work that is geared to the intellectual capabilities of most Secondary IV students. The basic philosophy promoted in this program is the "constructivist" view of the acquisition of knowledge. According to this perspective, science is not simply a set of laws carved in stone, but rather the result of mental efforts to develop an understanding of phenomena in the environment, based on previously acquired knowledge. Furthermore, the students are encouraged to become familiar with the interrelationships of science, technology and society by examining the social dimensions of science, the history of science, and environmental issues. As a result the students should be able to develop a realistic view of science, that is, an appreciation of the strengths and limitations of scientific inquiry.

This type of program calls for an interactive learning approach whereby the teacher guides the students as they use the scientific method to try to discover solutions to problems.

ORIENTATIONS


Using the scientific method to solve problems
Scientific Method
(experimental)
"Constructivist" Philosophy
Interrelationships of
Science, Technology, and Society:
- social dimensions of science
- history of science
- environmental concerns
Interactive approach

INTERACTIVE LEARNING

The teacher **guides** the students as they use the **scientific method** to try to **discover** solutions to various problems.

3. FOCUS OF LEARNING

3.1 Global Objective

Students require a minimum amount of scientific knowledge, because they are living and will continue to live in a scientific and technological society. The teacher's job is to provide students with the opportunity to "construct" the knowledge and intellectual skills that will help them become full-fledged members of society.

A scientific education involves acquiring not only knowledge but also an understanding of the conditions and methods that led to the development of models, laws and theories, and to the invention of technical objects.

Physics and chemistry cover a wide range of topics. It is obviously impossible to provide a complete overview of these subjects in 150 hours. If students are required to construct a great deal of knowledge, it will likely lead to a lecture-based approach in which the teacher is simply a conveyor of knowledge. This would run counter to the learning approach emphasized in this program and prevent teachers from helping students develop skills and attitudes.

THIS PROGRAM IS DESIGNED ABOVE ALL TO MAKE STUDENTS AWARE OF THE FUNDAMENTALS OF SCIENCE.

3.2 Goals

It is important that the related content of this program help students attain the global objective. The teacher should help them to construct their own knowledge and to develop skills and attitudes.

3.2.1 KNOWLEDGE

The students are encouraged to:

- understand the organization of concepts related to chemical and physical phenomena
- understand the interrelationships of chemistry, physics, and technology and their impact on people, society, and the environment
- become familiar with the nature of science, its capabilities and limitations
- discover situations that pose a danger to individuals, society, and the environment
- improve language skills

3.2.2 SKILLS

The students are encouraged to:

- gradually master technical skills
- acquire the ability to reason inductively ("scientific thought")
- work methodically and safely when doing scientific research

3.2.3 ATTITUDES

The students are encouraged to:

- develop an objective attitude toward science and scientists
- develop "scientific" attitudes
- develop ethical concerns regarding social issues and the environment
- develop an interest in science and technology outside school.

3.3 Subjects of Study and Integrating Themes

This program is centred on two equally important elements: certain aspects of physics and chemistry that affect individuals, society, the economy, and politics; and research methods used by scientists, notably physicists and chemists, to understand the environment. The authors have endeavoured to incorporate these two components into the wording of the objectives. Teaching strategies and learning activities are a reflection of the learning approach emphasized in this program.

The environment includes a vast number of natural and technical phenomena which may stimulate the students' interest and provide them with an opportunity to study various aspects of reality. This type of inquiry is central to this program. Through this type of investigation, students not only continue to construct knowledge, skills and attitudes, but also develop a certain view of the world of science and technology.

3.4 Objectives of the Program

Very little has been written on how to formulate and organize learning objectives for courses that are based on a "constructivist" view of science, the scientific method and the interrelationships of science, technology, and society. The authors have tried to incorporate this philosophy into the wording of the objectives and the learning activities. While this approach may create some difficulties, it is important to respect the philosophy of this program and to help students "construct" the learning content in accordance with that philosophy.

3.5 General Objectives

The three modules selected on the basis of expert feedback and the results of pilot projects deal with different aspects of the physical environment that are likely to interest students. Because of the interrelated nature of these topics, students will acquire a wide range of knowledge, skills, and attitudes that they can apply to a variety of situations. These modules also focus on the interrelationships of science, technology, and society. Thus, students acquire the basic scientific education they will need to live in a scientific and technological society and to study physics and chemistry at a more advanced level.

The general objective that appears at the beginning of each module reflects the orientations of this program.

3.6 Specific Objectives

The general objective of each module is described in greater detail by means of terminal objectives. These objectives are formulated in such a way that the students "construct" the related content (i.e. knowledge, skills, and attitudes) in accordance with the orientations of this program. The terminal objectives are presented in a certain sequence which can be changed according to the students' interests and progress.

The terminal objectives are compulsory for both Physical Sciences 416 and Physical Sciences 436. Evaluation for this material is the responsibility of the ministère. **In all cases, evaluation should take into account the orientations emphasized in the intermediate objectives, the learning activities and related content and should not extend beyond the scope of these three items.**

Each terminal objective is divided into intermediate objectives. These objectives are also presented in a certain sequence which can be adapted to the interests, abilities, and learning style of each student. They should be viewed as a series of useful strategies designed to help the students attain the terminal objectives.

The unstarred intermediate objectives are part of the core curriculum (CC), which means that they are compulsory in both Physical Sciences 416 and Physical Sciences 436. Intermediate objectives that supplement the core curriculum (the bridge) and that are prerequisites for Secondary V Physics and Chemistry are preceded by an asterisk (*). Intermediate objectives preceded by two asterisks (**) are regarded as enrichment activities in both Physical Sciences 416 and Physical Sciences 436.

OBJECTIVES OF THE PROGRAM

Module I: Properties and Structures

MODULE OBJECTIVE

TO EXPLORE the properties of matter and a method of representing and classifying matter, using the scientific method.

TERMINAL OBJECTIVES

THE STUDENT WILL BE ABLE TO:

1. **Communicate the results of a documentary research project on the properties, structure, or classification of matter by using correct language and showing how the scientific, technological, and social aspects of this topic are interrelated.**
2. **Identify some of the characteristic properties of objects in his/her environment, using his/her own method.**
3. **Explain the different changes that matter can undergo, based on what he/she has observed while doing scientific work.**
4. **Analyze different atomic models proposed by various scientists by taking into account the properties of matter he/she has examined while doing scientific work.**
5. **Analyze the periodic table, based on the properties of matter he/she has examined while doing scientific work and on an atomic model with which he/she has become familiar.**
6. **Represent the molecule of a pure substance, using a model that takes into account the properties of matter, an atomic model, and the classification of elements he/she has examined while doing scientific work.**

OBJECTIVES OF THE PROGRAM

Module II: Electrical Phenomena

MODULE OBJECTIVE

TO EXPLORE the electrical properties of matter as well as the ways in which the production, transformation, and use of electric energy affect the environment and the lives of Quebecers, using the scientific method.

TERMINAL OBJECTIVES

THE STUDENT WILL BE ABLE TO:

1. Measure at least one of the variables associated with electric circuits, using an instrument that he/she has constructed.
2. Analyze the characteristics of a magnetic field that were examined as part of his/her scientific work.
3. Analyze the variables associated with various combinations of circuit elements that he/she used while doing scientific work.
4. Determine the amount of electric energy consumed by a circuit, using techniques with which he/she has become familiar.
5. Demonstrate the law of conservation of energy with which he/she has become familiar while doing laboratory experiments.
6. Make an environmental impact study of certain types of energy transformations.
7. Make a study of how electrification has affected Québec society.

OBJECTIVES OF THE PROGRAM

Module III: Ionic Phenomena

MODULE OBJECTIVE

TO EXPLORE the properties of chemical substances, transformations involving these substances, and the way in which their use affects the environment and the lives of Quebecers, using the scientific method.

TERMINAL OBJECTIVES

THE STUDENT WILL BE ABLE TO:

1. Communicate the results of an experimental research project focusing on at least one acid, one base, or one salt, using appropriate language.
2. Explain the properties of acids, bases, and salts that he/she has observed while doing scientific work dealing with various transformations or reactions involving these substances.
3. Analyze variables associated with the aqueous solutions (kept at constant temperature) that he/she used while doing scientific work.
4. Determine the acidity and the alkalinity of a solution, based on the properties of certain indicators and using the pH scale.
5. Analyze chemical changes, based on the law of conservation of matter with which he/she has become familiar while doing laboratory experiments.
6. Make an environmental impact study of the use of matter.
7. Make a study of how the development of the chemical industry has affected Québec society.

3.7 Learning Activities

The learning activities associated with an intermediate objective are learning situations that the teacher could use to help the students achieve that intermediate objective. They are presented in a certain sequence and reflect the orientations of the program to varying degrees. Each set of learning activities should be regarded merely as a list of suggestions. These activities can be modified as long as they remain consistent with the orientations of the program.

3.8 Related Content

The related content for each intermediate objective consists of a skill, a concept, and an attitude emphasized in that section of the course. This information is designed to help teachers specify and plan their educational approach and methods of evaluation. As with the intermediate objectives and learning activities, it should be regarded simply as a list of suggestions.

A list of the skills and attitudes emphasized in this program is presented in Appendix I. The alphanumeric code indicated in parentheses refers to the taxonomy presented in Appendix II.

3.9 Suggested Teaching Plan

A certain number of elements that teachers may want to consider when planning their educational approach are suggested for each intermediate objective. These elements are listed below.

PREREQUISITES:	Review of the skills or knowledge that students should normally have begun to develop or acquire in one or more previous courses.
TEACHING STRATEGY:	One or more teaching techniques suitable for the suggested learning activities. The techniques selected and the order in which they are used constitute a teaching strategy and are a function of the suggested learning situation.
DURATION:	An indication of the time needed to help the student attain an intermediate objective. Two times are indicated in parentheses. The first applies to Physical Sciences 436, while the second refers to Physical Sciences 416. The time allotted to objectives related to research projects (Terminal Objective 1 of each module)

is the same for Physical Sciences 416 and Physical Sciences 436. A total of one hundred fifty (150) hours is allotted to the compulsory material in Physical Sciences 416, as stipulated in the Basic School Regulations. A total of one hundred fifty (150) hours is allotted to the compulsory material in Physical Sciences 436, which consists of the core curriculum and supplementary objectives, or bridge (B). The durations indicated include the time needed to evaluate student learning.

EVALUATION: An indication of the area(s) that a teacher might focus on during formative evaluation to determine whether students have attained an intermediate objective. While these areas should be emphasized, other aspects can also be evaluated.

EQUIPMENT: A list of instruments, materials, and products that should be made available to the students, depending on the suggested learning activities.

PREVENTIVE MEASURES: Information on health and safety measures and environmental protection. Individual protective equipment should be chosen in accordance with the information under this heading. See: **Health and Safety in the Natural Science Laboratory** and **Guide de manipulation et d'élimination des substances dangereuses dans les établissements scolaires** (full references listed in Chapter 8 under **RELATED DOCUMENTS**).

SUGGESTED REFERENCES: Some modules include a list of suggested books, audiovisual materials, and educational software designed for teachers and/or students and which may help the latter attain an intermediate objective. Videocassette recordings identified with an asterisk can be obtained through school board media centres or from:

Lise Fillon
Québec School Television
Radio Québec
600, Fullum St., 5th Floor
Montréal, Québec
H2K 3L6
(514) 521-2424 Ext. 4219

TEACHER'S NOTES: Teachers should feel free to add any pertinent information to this list on the basis of their own experiences. This information should be updated regularly.

3.10 Projects

Students are required to do at least one project per module. A list of suggested projects as well as instructions on how to carry them out are provided in the first terminal objective of each module.

Students can carry out the project as they begin the module, while they are studying it, or once they have completed it. Class presentations on the various projects will provide additional information, and lead to questions which can be answered during that period or in subsequent lessons.

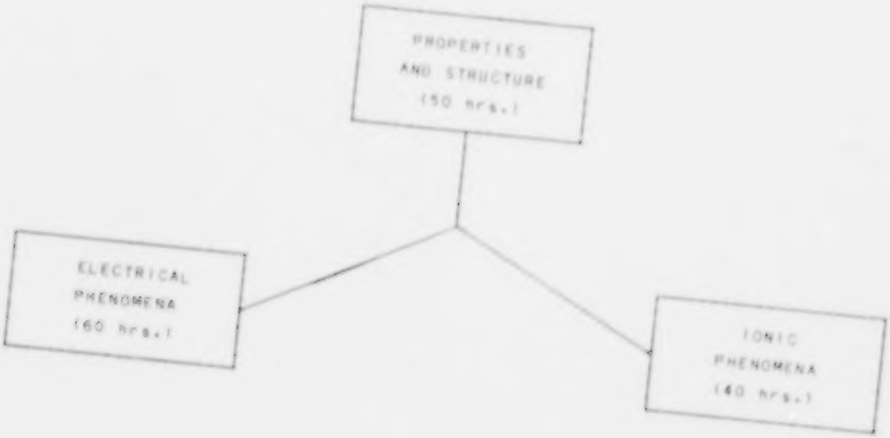
Students are also encouraged to take part in science fairs and other extra-curricular activities related to the material covered in this program.

4. STRUCTURE OF THE PROGRAM AND LEARNING CONTENT

The program entitled "THE DISCOVERY OF MATTER AND ENERGY" consists of three compulsory modules. The material in each module is presented in a certain sequence that provides students with meaningful learning situations that are consistent with the orientations of the program.

The following diagram illustrates the sequence of these modules. After studying the first module (Properties and Structures), students can choose either the module on electrical phenomena or the module on ionic phenomena, depending on their interests.

THE DISCOVERY OF MATTER
AND ENERGY


PROPERTIES
AND STRUCTURE
(50 hrs.)
ELECTRICAL
PHENOMENA
(60 hrs.)
IONIC
PHENOMENA
(40 hrs.)

4.1 Structure of Physical Sciences 416

COMPULSORY CONTENT CORE CURRICULUM (CC)	ENRICHMENT CONTENT (E)		
Properties and Structure	*	OR	**
Electrical Phenomena	*	OR	**
Ionic Phenomena	*	OR	**
Prerequisites for Secondary V Physical Sciences	OR Project (CBE)		

Physical Sciences 416 is intended for all Secondary IV students who do not plan on opting for the college-level Natural Sciences concentration or for a vocational program with physics and/or chemistry prerequisites. The compulsory content for this course consists of a core curriculum (CC) that students will "construct" over different periods of time, depending on their interests and their abilities, and the enrichment content (E) they are assigned.

Students who can cover the core curriculum in less time than the one hundred fifty (150) hours normally devoted to the compulsory content, or who have more than one hundred fifty (150) hours will be assigned the enrichment content. They will be able to "construct" the content that supplements the core curriculum (CC) and that prepares them for Secondary V Physics and/or Chemistry. These supplementary objectives make up the bridge (B) and are starred (*). The students can also explore enrichment objectives (**) or do a project, specially developed for them by the teacher, in which they must make use of the educational resources in their community (community-based education or CBE).

The objectives associated with the core curriculum (CC) are unstarred. The objectives that supplement the core curriculum (CC) and that serve as a bridge (B) between Physical Sciences 416 and the Secondary V Physics and Chemistry programs are preceded by an asterisk (*). As for the enrichment objectives, they are preceded by two asterisks (**) and can be covered by students in the regular path (416) as well as those in the enriched path (436).

4.2 Structure of Physical Sciences 436

COMPULSORY CONTENT		ENRICHMENT CONTENT (E)
CORE CURRICULUM (CC)	SUPPLEMENTARY CONTENT (BRIDGE)	
Properties and Structure	*	**
Electrical Phenomena	*	**
Ionic Phenomena	*	**
Prerequisites for Secondary V Physics and Chemistry		OR others** (CO) OR Project (CBE)

Physical Sciences 436 is designed for students who are capable of covering this material or who intend to study physics and chemistry in Secondary V and in CEGEP and are capable of doing so. The compulsory content for this course consists of prerequisites for the Secondary V Physics and Chemistry programs, namely the same core curriculum (CC) that applies to Physical Sciences 416, and the supplementary content that serves as a bridge (B) between Physical Sciences 416 and the Secondary V Physics and Chemistry programs.

Students who are more interested or gifted or who have more time than the 150 hours normally devoted to the compulsory content will also be able to explore enrichment content. This may involve examining the topics (modules) of the program in greater depth by covering the enrichment objectives of the program (**) or other objectives, chosen by the teacher (CO), which will prepare them for the Secondary V Physics and/or Chemistry programs. The teacher may also assign a project in which they must make use of the educational resources in their community (CBE).

The objectives and learning activities that constitute the core curriculum are unstarred, while those that make up the supplementary content, namely the bridge (B), are preceded by an asterisk (*). Enrichment objectives are preceded by two asterisks (**).

4.3 Module on Properties and Structure

The study of matter is a vast undertaking. The students' physical environment is a source of wonder that sparks their curiosity. By making their own observations, conducting their own experiments, and reading up on the subject, they will be able to describe the properties and structure of matter more accurately.

4.4 Module on Electrical Phenomena

Because of the pervasiveness of technology, the individual has become increasingly dependent on specialists. If people understand the uses of electricity, the concept of energy conservation, and the social, economic, and political issues associated with electrical energy, they can become more autonomous.

4.5 Module on Ionic Phenomena

By exploring acidic, basic and saline solutions and chemical substances in general, the students become aware of the social and environmental impact of chemistry and technology, discover the concept of the conservation of matter, and develop a greater concern for environmental protection and resource conservation.

5. PROGRAM-GUIDE

Module I
Properties and Structures

MODULE OBJECTIVE: TO EXPLORE the properties of matter and a method of representing and classifying matter, using the scientific method.

SPECIFIC OBJECTIVES
(Terminal and intermediate)

THE STUDENT WILL BE ABLE TO:

1. **Communicate the results of a documentary research project on the properties, structure, or classification of matter by using correct language and showing how the scientific, technological, and social aspects of this topic are interrelated.**

   1.1 Specify the limits of a research topic.

PREREQUISITES:

RELATED CONTENT:

- SKILL: Recognizing a problem. (C-1)
- KNOWLEDGE: Preparing a scientific research project. (A-7)
- ATTITUDE: Intellectual curiosity. (H-5)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Presentation, brainstorming, class discussion, individual work.
B. DURATION: (75/75) minutes in class + work at home.
C. EVALUATION: Student's involvement in project.
D. MATERIALS: Reference materials.
E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

SARMANT, Jean-Pierre, **Dictionnaire de Physique**, Hachette, 1981, Edition revue et corrigée 1983, 312 p.

LEARNING ACTIVITIES

THE STUDENT:

1.1.1 Describes what matter is, using his/her knowledge.

1.1.2 Distinguishes between science and technology.

1.1.3 Describes the goal of a research project.

1.1.4 Lists the ways in which society makes use of science and technology.

1.1.5 Identifies some of the scientific and technological resources available to him/her (e.g., laboratories, industries, people, educational establishments) and that can be used in scientific research.

1.1.6 Lists research topics that deal with the properties, structure, and classification of matter.

1.1.7 Chooses a research topic from among the subjects listed in 1.1.6.

1.1.8 Determines which aspects of the topic he/she will research.

1.1.9 Forsees the equipment and reference materials that may be needed to carry out his/her research, taking into account the available resources.

1.1.10 Lists the contexts in which the results of a research project can be communicated.

1.1.11 Chooses the context in which the results of the research project will be communicated.

1.1.12 Has the research topic approved.

List of Research Topics
Related to Terminal Objective 1

The following is a list of suggested topics. The students should draw up their own list of topics before the class discussion. If, however, the teacher is not satisfied with the students' suggestions, he/she can use this list or add to it.

Students are to study the relationship between the properties, structure, and/or classification of matter and any of the following aspects of human existence:

1. Daily Life:
   a) ensuring good nutrition
   b) making clothes
   c) manufacturing tools and consumer goods
   d) making proper use of air and water
   e) manufacturing and using construction materials
   f) manufacturing and using materials related to transportation
   g) ensuring good health

2. Nuclear Science:
   a) medical applications
   b) energy production
   c) military applications
   d) knowledge of the physical universe
   e) food preservation

3. Waste management:
   a) radioactive waste
   b) domestic waste
   c) industrial waste
   d) agricultural waste

   Effects of Waste Management on:
   a) the atmosphere
   b) the hydrosphere
   c) the lithosphere

4. Resource Conservation:
   a) energy conservation
   b) conservation of resources used to make various technical objects (e.g., wood, ore)

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

1.2 Draw up a research plan.

PREREQUISITES:

1.1

RELATED CONTENT:

- SKILL: Developing a research procedure. (C-4)
- KNOWLEDGE: Research procedure. (A-7)
- ATTITUDE: Willingness to clarify problems. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Individual work, meetings between the teacher and each student to discuss the plan.
B. DURATION: (35/75) minutes in class + work at home.
C. EVALUATION: Student's research plan.
D. MATERIALS: Reference materials.
E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

Video: **Perspectives in Science**, 4 tapes - 360 min, N.F.B. [illegible].

LEARNING ACTIVITIES

THE STUDENT:

1.2.1 Determines the goal of the research project, specifying the aspects that he/she will study (identifying the problem).

1.2.2 Draws up a list of reference materials (e.g. books and miscellaneous publications, audio-visual materials, interviews, software programs) that could be useful for his/her research.

1.2.3 Foresees the way in which the results of the research project are to be communicated, in light of the available resources.

1.2.4 Prepares a schedule of the work to be done for this project.

1.2.5 Has the research plan approved.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

1.3 Carry out documentary research.

PREREQUISITES:

1.2

RELATED CONTENT:

- SKILL: Generalizing. (F-1)
- KNOWLEDGE: Learning how to follow a research procedure. (A-7)
- ATTITUDE: Willingness to interpret information. (M-3)

SUGGESTED TEACHING PLAN:

LEARNING ACTIVITIES

THE STUDENT:

1.3.1 Finds reference materials that are pertinent to his/her research.

1.3.2 Questions resource-persons who can help him/her with the research project, if necessary.

1.3.3 Gathers and organizes information that is useful for the research project.

1.3.4 Analyzes the information gathered in 1.3.3, in accordance with the goal of the research project.

1.3.5 Draws conclusions based on his/her analysis, in accordance with the goal of the research project.

TEACHER'S NOTES:

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Individual work, interviews, field trips.
B. DURATION: (75/225) minutes in class
+ free time + work at home.
C. EVALUATION: Student's research methods.
D. MATERIALS: Reference materials, materials
that can be used to build
models, camera, video-cassette
recorder,... .
E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

Video: **Perspectives in Science**, 4 tapes - 102 min.
N.F.B.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

1.4 Communicate the results of the documentary research project.

PREREQUISITES:

1.3

RELATED CONTENT:

- SKILL: Communicating. (T-4)
- KNOWLEDGE: Rules for writing a research report. (A-7)
- ATTITUDE: Conscientiousness. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Meetings between the teacher and each student, student's presentation.

B. DURATION: (250/250) minutes in class + work at home.

C. EVALUATION: Student's presentation of results.

D. MATERIALS: Audio-visual material.

E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

DORIN, H. **Chemistry: The Study of Matter.** Fairfield, N.J.: Cebeco Standard Publishing, 1982, pp. 3-8.

LEARNING ACTIVITIES

THE STUDENT:

1.4.1 Writes a research report, using correct language.

1.4.2 Indicates the method used to gather information.

1.4.3 Uses tables, graphs, and other methods of presenting information.

1.4.4 Ensures that the equipment needed to communicate the results is available (e.g., projector, tape recorder, films, video-cassette recorder, video tapes, photographs, slides).

1.4.5 Presents the results of the research project, using the methods chosen in 1.2.3.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

2. **Identify some of the characteristic properties of objects in his/her environment, using his/her own method.**

   2.1 Identify some of the properties of objects and substances in his/her environment.

PREREQUISITES:

Physical Sciences 214

RELATED CONTENT:

- SKILL:	Observing. (B-1)
- KNOWLEDGE:	Odour, colour, hardness, magnetism, mass, volume, density, solubility, melting point, boiling point, specific heat, etc. Concept of a non-characteristic property. (A-1)
- ATTITUDE:	Willingness to interpret information. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:	Laboratory work, class discussion.
B. DURATION:	(50/75) minutes.
C. EVALUATION:	Student's observations.
D. MATERIALS:	Objects from the students' environment.
E. SAFETY MEASURES:	In accordance with the objects used.

SUGGESTED REFERENCES:

TOON, E.; ELLIS, G. and BROOKIN, J. **Foundations of Chemistry.** Toronto: Holt, Rinehart and Winston of Canada Limited, 1968, pp. 63-66.

*Videos: **EUREKA SERIES**, TV Ontario, 4 programs: **16. Molecules in Solids; 17. Molecules in Liquids; 18. Evaporation and Condensation; 19. Expansion and Contraction.**

LEARNING ACTIVITIES

THE STUDENT:

2.1.0 Recalls the description of the characteristics of the atmosphere (Physical Sciences 214).

Recalls how properties are used to identify minerals and rocks (Physical Sciences 214).

Recalls the description of the characteristics of a solution (Physical Sciences 214).

Recalls the properties of heat (Physical Sciences 214).

2.1.1 Selects several different types of objects and substances from his/her environment.

2.1.2 Identifies the similarities in the objects and substances selected.

2.1.3 Concludes that all objects have mass and occupy a volume.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

2.2 Determine the characteristic properties of given substances.

PREREQUISITES:

2.1

RELATED CONTENT:

- SKILL: Organizing data. (D-2)
- KNOWLEDGE: Concept of a characteristic property. Specifying properties of certain substances or groups of substances: water turns cobalt chloride red; acidic solutions turn neutral litmus paper red and conduct electricity; basic solutions turn neutral litmus paper blue and conduct electricity; hydrogen burns (explodes) when near a glowing splint; oxygen revives a glowing splint; carbon dioxide makes limewater cloudy; ammonia can be used to detect hydrogen chloride; substances crystallize in different ways. (A-1)
- ATTITUDE: Objectivity. (m-5)

LEARNING ACTIVITIES

THE STUDENT:

2.2.1 Lists some of the properties that could be used to describe given substances.

2.2.2 Identifies other properties that could be used to describe these substances, by means of a suggested procedure.

2.2.3 Records the name and the properties of each substance in a table.

2.2.4 Completes the table, using a reference manual if necessary.

2.2.5 Proposes a definition of "characteristic property," based on this table.

2.2.6 Classifies the properties in the table as either characteristic or non-characteristic.

2.2.7 Justifies this classification.

substances crystallize in different ways.
- ATTITUDE: Objectivity. (M-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY: Demonstration, laboratory work, class discussion.
B. DURATION: (150/200) minutes.
C. EVALUATION: Student's knowledge of the characteristic properties of given substances.
D. MATERIALS: Matches, wooden splints, test tubes, corks, magnifying glass or binocular microscope, watch glass, power supply, conducting wire, light bulb or galvanometer, carbon electrodes.
Gases: CO_2, H_2, O_2.
Liquids: H_2O, 0.5 mol/L solutions of NaOH and HCl, 6 mol/L solutions of NH_3 and HCl.
Solids: Fe, S, Ni, NaCl crystals, $CaCO_3$, $CuSO_4$.
Indicators: Limewater, strips of $CoCl_2$ paper, strips of neutral litmus paper.
E. SAFETY MEASURES: Fire, acidic and basic solutions, toxic substances, measures to protect the environment.

SUGGESTED REFERENCES:

ORD, Dennis. **Exploring Chemistry.** Hightstown, N.J.: McGraw-Hill Ryerson Limited, 1986, pp. 8-15.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

2.3 Identify a substance on the basis of its characteristic properties.

PREREQUISITES:

2.1, 2.2

RELATED CONTENT:

-	SKILL:	Developing an experimental procedure. (C-4)
-	KNOWLEDGE:	Rules for developing an experimental procedure. (A-7)
-	ATTITUDE:	Creative approach. (D-5)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Laboratory work, individual work.

B.	DURATION:	(125/150) minutes in class + work at home.
C.	EVALUATION:	Student's experimental procedure.
D.	MATERIALS:	Reference manual and one or more of the substances chosen from the list in 2.2.
E.	SAFETY MEASURES:	Disposal of residues and toxicity of products, measures to protect the environment.

SUGGESTED REFERENCES:

DONOVAN, T.; POOLE, M. and TACK, D. **Chemicals in Action.** Toronto: Holt, Rinehart and Winston of Canada Limited, 1987, pp. 31-45.

LEARNING ACTIVITIES

THE STUDENT:

2.3.1 Formulates a hypothesis regarding the nature of given substances.

2.3.2 Predicts the characteristic properties of these substances.

2.3.3 Develops an experimental procedure to test these predictions.

2.3.4 Carries out the experiment in a laboratory.

2.3.5 Writes a report on the experiment he/she has conducted.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

2.4 Justify the use of a substance in the manufacture of certain consumer goods (technical objects) on the basis of the properties of that substance.

PREREQUISITES:

2.2

RELATED CONTENT:

- SKILL: Generalizing. (F-3)
- KNOWLEDGE: Relationship between the use of these consumer goods and the properties of the substances used to make them. (A-10)
- ATTITUDE: Sense of responsibility (concern for the environment). (I-5)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY: Group work, individual work.
B. DURATION: (50/75) minutes in class + work at home.
C. EVALUATION: Student's argumentation.
D. MATERIALS: Reference materials pertinent to the consumer goods chosen.
E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

*Videos: **ABOUT SCIENCE SERIES**, TV Ontario, five 5-minute programs:
1. **Preparation of Oxygen;**
2. **Physical Properties of Oxygen;**
3. **Chemical Properties of Oxygen;**
4. **Preparation of Carbon Dioxide;**
5. **Properties of Carbon Dioxide.**

LEARNING ACTIVITIES

THE STUDENT:

2.4.1 Identifies various consumer goods[1] that have the same function.

2.4.2 Identifies the substances used to manufacture these consumer goods.

2.4.3 Identifies the properties that justify the use of each substance in the manufacture of these consumer goods.

2.4.4 Identifies the advantages and disadvantages of using the various substances.

2.4.5 Compares the technologies used in producing these consumer goods.

2.4.6 Compares the different amounts of energy needed to produce these consumer goods.

2.4.7 Describes how the use of various substances affects the economy and the environment.

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[1] Examples:
- Aluminium, steel, cast iron, or glass skillets
- Tar or wood shingles; tiles
- Bottles, cans, or plastic containers
- Fibreglass or metal car body
- Optical fibre, copper wire, aluminium wire
- Asphalt or concrete roads
- Steel or magnesium wheel rims
- Wood, aluminium, or plastic windows
- Fuel: coal, wood, oil, gas
- Solid or liquid propellant
- Laser-read sound disk (i.e., compact disc) or stylus and vinyl record
- Liquid crystals or cathode ray tube displays

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

5. **Explain the different changes that matter can undergo, based on what he/she has observed while doing scientific work.**

   5.1 Formulate hypotheses regarding the causes of the changes in objects or substances in his/her environment.

PREREQUISITES:

2

RELATED CONTENT:

- SKILL: Formulating hypotheses. (C-2)
- KNOWLEDGE: Causes of the changes. (A-3)
- ATTITUDE: Creative approach. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY: Group work, class discussion.
B. DURATION: (50/75) minutes.
C. EVALUATION: Student's ability to formulate a hypothesis.
D. MATERIAL(S): Material that the students bring to class.
E. SAFETY MEASURES: Caution, measures to protect the environment.

SUGGESTED REFERENCES:

METCALFE, H., WILLIAMS, J. and CASTKA, J. **Modern Chemistry.** Toronto: Holt, Rinehart and Winston of Canada Limited, 1986, pp. 51-57 (section on changes in matter).
ORD, Dennis. **Exploring Chemistry.** Hightstown, N.J.: McGraw Hill-Ryerson Limited, 1986, p. 12 (section on sublimation).
*Videos: **ABOUT SCIENCE SERIES,** TV Ontario, four 5-minute programs:
6. Distillation; 7. Combustion;
8. Electroplating; 30. Dry Ice.

LEARNING ACTIVITIES

THE STUDENT:

5.1.1 Finds objects or substances in the environment which seem to be undergoing or to have undergone changes.

5.1.2 Describes the changes in these objects or substances.

5.1.3 Identifies the possible cause(s) of these changes.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and intermediate)

THE STUDENT WILL BE ABLE TO:

3.2 Classify the changes in various substances as either physical or chemical changes.

PREREQUISITES:

3.1

RELATED CONTENT:

- SKILL: Interpreting data. (D-3)
- KNOWLEDGE: Signs of change, physical and chemical changes. (A-6)
- ATTITUDE: Sense of responsibility (concern for health and safety). (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY: Group work, laboratory work, class discussion, demonstration.
B. DURATION: (125/150) minutes.
C. EVALUATION: Student's method of classification.
D. MATERIALS: Test tubes, magnet, tweezers, spatula, glass slides, test tube rack, matches, beakers, safety goggles.

Substances: Fe, S, Mg, $CaCO_3$ (chalk), HCl 1 mol/L, $CaCl_2$ 1 mol/L, NaOH 1 mol/L, sealed tube of I_2, hot and cold water.

E. SAFETY MEASURES: Handling HCl and NaOH, glassware, disposal of residues, toxicity of products, measures to protect the environment.

SUGGESTED REFERENCES:

JOLLIFFE, L.; GORING, P.; JONES, R. and KILLAM, D. **Insights 9.** Toronto: Copp Clark Pitman Ltd., 1986, pp. 105-193.
ORDRE DES CHIMISTES DU QUÉBEC. **Laboratory Safety Handbook.** Ottawa: Chemical Institute of Canada, 1987.
16mm Film: **Molecules: A First Film**, 10 min, International Tele-Film.
Videos: - ***About Science Tape 2**, 25 min, TV Ontario.
- **Introducing Chemistry: Types of Chemical Changes**, 14 min, Coronet.

LEARNING ACTIVITIES

THE STUDENT:

3.2.1 Determines some of the properties of given substances before subjecting them to change.

3.2.2 Brings about these changes by following a suggested experimental procedure.

3.2.3 Determines the properties of these substances after they have undergone the change.

3.2.4 Compares the properties of these substances before and after they have undergone change.

3.2.5 Suggests an empirical definition of a physical change and a chemical change.

3.2.6 Classifies these changes as either physical or chemical changes.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

5.3 Describe a pure substance as a compound or an element, after conducting an experiment.

PREREQUISITES:

5.2 and module on mixtures in Physical Sciences 214.

RELATED CONTENT:

-	SKILL:	Interpreting data. (D-3)
-	KNOWLEDGE:	Compounds, elements, pure substances. (A-3)
-	ATTITUDE:	Sense of responsibility (concern for health and safety). (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Group work, laboratory work, class discussion.

B. DURATION: (125/150) minutes.

C. EVALUATION: Student's ability to carry out the experiment.

D. MATERIALS: Bunsen burner, ring stand, ring, pipe stem triangle, crucible, tongs, balance. Substances: Unoxidized powdered copper or copper turnings.

E. SAFETY MEASURES: Heating, glassware.

SUGGESTED REFERENCES:

ALLEN, M. "Classification of Matter - A Paper Clip Simulation." **The Science Teacher** 50 (3): 76 March 1983.

LEARNING ACTIVITIES

THE STUDENT:

5.3.0 Recalls the definitions of a pure substance, a mixture, and a solution (Physical Sciences 214).

5.3.1 Determines the properties of a pure substance before it is heated.

5.3.2 Heats the pure substance in accordance with the suggested experimental procedure.

5.3.3 Determines the properties of the substance obtained after it is heated.

5.3.4 Compares the properties of the substance before it is heated with those of the substance after it is heated.

5.3.5 Determines whether the change is chemical or physical.

5.3.6 Compares the mass of the substance before it is heated with that of the substance after it is heated.

5.3.7 Differentiates between an element and a compound.

5.3.8 Formulates a hypothesis regarding the nature of the substance before and after it is heated heated, using the words **element** and **compound**.

5.3.9 Justifies this hypothesis.

5.3.10 Compares his/her hypothesis and justification with those of the other students.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

3.4 Analyze a compound experimentally.

PREREQUISITES:

3.3

RELATED CONTENT:

- SKILL: Interpreting data. (D-3)
- KNOWLEDGE: Method for analyzing a compound, elements that make up a compound, chemical change. (A-7)
- ATTITUDE: Willingness to interpret information. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Laboratory work, individual work, class discussion.

B. DURATION: (75/100) minutes in class + work at home.

C. EVALUATION: Student's laboratory work.

D. MATERIALS: Bunsen burner, test tube, bent glass tube, one-hole stopper, mortar and pestle, pneumatic tank, rubber tubing, gas bottle and cover plate, balance.
Substances: Substances synthesized in 3.1, charcoal, limewater.

E. SAFETY MEASURES: Heating, glassware.

SUGGESTED REFERENCES:

JOLLIFFE, L.; GORING, F.; JONES, R. and KILLAM, G. **Insights 9.** Mississauga, Ont.: Copp Clark Pitman Ltd., 1988, pp. 105-193.

LEARNING ACTIVITIES

THE STUDENT:

3.4.1 Tests the hypothesis formulated in 3.3.8 by following the suggested experimental procedure.

3.4.2 Determines the properties of the substances obtained.

3.4.3 Compares the properties of the substances obtained with those of the substance before it is heated (3.3.1).

3.4.4 Formulates a hypothesis regarding the chemical composition of the compound he/she has analyzed.

3.4.5 Justifies his/her hypothesis.

3.4.6 Compares his/her hypothesis with the one generally accepted.

3.4.7 Describes the changes observed in 3.3 and 3.4 in his/her own words (using a "word equation").

3.4.8 Writes a report of the entire experience (i.e., the experiments and analyses carried out in 3.3 and 3.4).

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

**5.5 Demonstrate the efficiency of means used to bring about or prevent chemical changes, after conducting experiments.

PREREQUISITES:

5.2

RELATED CONTENT:

-	SKILL:	Interpreting data. (S-5)
-	KNOWLEDGE:	Catalysts, inhibitors, technological means. (K-10)
-	ATTITUDE:	Willingness to interpret information. (A-5)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Laboratory work, individual work, class discussion.
B. DURATION: (50/75) minutes.
C. EVALUATION: Student's report.
D. MATERIALS: Depending on the means suggested.
E. SAFETY MEASURES: Depending on the means suggested.

SUGGESTED REFERENCES:

FERRARA, Jean. "La cuisine, chimie sauvage." **Science et vie**, N° 804, (septembre 1984), pp. 50-51.
LEDBETTER, E. and YOUNG, J. **Keys to Chemistry**. Addison-Wesley Publishing Company, 1977, p. 54.
ORD, Dennis. **Exploring Chemistry**. Hightstown, N.J.: McGraw-Hill Ryerson Ltd., 1986, pp. 48-55.

LEARNING ACTIVITIES

THE STUDENT:

5.5.1 Suggests means of preventing chemical changes.

5.5.2 Suggests means of bringing about chemical changes.

5.5.3 Verifies the efficiency of some of these means by following the suggested experimental procedure.

5.5.4 Illustrates an industrial production process (metallurgical or other) that involves chemical changes.

5.5.5 Lists everyday technological applications that bring about or prevent chemical changes.

5.5.6 Writes a report on the efficiency of these means.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and intermediate)

THE STUDENT WILL BE ABLE TO:

**3.6 Demonstrate the efficiency of the means used to bring about or prevent physical changes, after conducting experiments.

PREREQUISITES:

3.2

RELATED CONTENT:

- SKILL: Interpreting data. (D-5)
- **KNOWLEDGE:** Insulators, lubricants, protective substances, etc. (A-10)
- ATTITUDE: Willingness to interpret information. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Laboratory work, individual work, class discussion.
B. DURATION: (50/75) minutes.
C. EVALUATION: Student's report.
D. **MATERIALS:** Depending on the means suggested.
E. SAFETY **MEASURES:** Depending on the means suggested.

SUGGESTED REFERENCES:

JOLLIFFE, L.; GORING, F.; JONES, R. and KILLAM, B. **Insights 9.** Mississauga, Ont.: Copp Clark Pitman Ltd., 1988, pp. 56-57, pp. 60-61.
NAUZE, Olivier. "L'âge du cristal", **Science et vie,** N° 836, (mai 1987), pp. 102-107.

LEARNING ACTIVITIES

THE STUDENT:

3.6.1 Suggests means of preventing physical changes.

3.6.2 Suggests means of bringing about physical changes.

3.6.3 Verifies the efficiency of some of these means by following the suggested experimental procedure.

3.6.4 Illustrates an industrial production process (metallurgical or other) that involves physical changes.

3.6.5 Lists everyday technological applications that bring about or prevent physical changes.

3.6.6 Writes a report on the efficiency and usefulness of these means.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

3.7 Describe the impact of physical and chemical changes on the environment, health, the economy, and society.

PREREQUISITES:

2.4

RELATED CONTENT:

- SKILL: Generalizing. (F-3)
- KNOWLEDGE: Impact of changes (e.g. phase changes, combustion). (A-10)
- ATTITUDE: Sense of responsibility. (I-5)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Group work, individual work, class discussion.
B. DURATION: (50/75) minutes in class + work at home.
C. EVALUATION: Student's description.
D. MATERIALS: Reference materials.
E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

ORD, Dennis. **Exploring Chemistry.** Hightstown, N.J.: McGraw-Hill Ryerson Ltd., 1986, pp. 59-63.

LEARNING ACTIVITIES

THE STUDENT:

3.7.1 Lists physical and chemical changes that can affect the environment, health, the economy, or society.

3.7.2 Describes how these changes affect the environment, health, the economy, or society.

3.7.3 Assesses the impact of these changes on the environment, health, the economy, or society.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

4. **Analyze different atomic models proposed by various scientists by taking into account the properties of matter he/she has examined while doing scientific work.**

   4.1 Compare the discontinuous (Democritus) and the continuous (Aristotle) theories of the structure of matter.

PREREQUISITES:

History 214

RELATED CONTENT:

- SKILL: Formulating hypotheses. (C-2)
- KNOWLEDGE: Democritus' and Aristotle's theories of the structure of matter, models. (A-9)
- ATTITUDE: Critical attitude. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY: Individual work, class discussion.
B. DURATION: (50/75) minutes in class + work at home.
C. EVALUATION: Student's argumentation.
D. MATERIALS: Reference materials.
E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

Lapp, Ralph E. **Matter**. New York: Time Inc., 1965.
Smith, Sheldon. **The Atoms and Beyond: A New Introduction to Modern Physical Science**. New York: Boston Science and Math, April 1961. Chapter 2, pp. 10-26.

Educational Software: Structure of Matter, [illegible].

Videos: **CONCEPTS IN SCIENCE SERIES**, TV Ontario, Tape 4 - Structure of the Atom, a series of six 15-minute programs: 1. The Earliest Models; 2. Smaller than the Smallest; 3. The Rutherford Model; 4. The Bohr Model; 5. Spectra; 6. The Wave-Mechanical Model. (Teacher's guide included).

CONCEPTS IN SCIENCE SERIES, TV Ontario, Tape 5 - Electron Arrangement and Bonding, a series of six 15-minute programs: 1. Introducing the Pioneers; 2. The Rutherford-Bohr atom; 3. Electron Arrangement; 4. How Atoms Bond; 5. Molecular Substances and Covalent Crystals; 6. Metals and Ionic Solids. (Teacher's guide included).

LEARNING ACTIVITIES

THE STUDENT:

4.1.1 Formulates a hypothesis regarding the structure of matter, using the words **continuous** and/or **discontinuous**.

4.1.2 Justifies his/her hypothesis.

4.1.3 Becomes aware of Democritus' discontinuous hypothesis regarding the structure of matter.

4.1.4 Becomes aware of Aristotle's reasons for rejecting Democritus' atomic model.

4.1.5 Assesses the scientific value of Aristotle's reasons, using his/her knowledge.

4.1.6 Justifies the use of models in science.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

4.2 Represent a chemical change, using a model.

PREREQUISITES:

3.3, 3.4, 4.1

RELATED CONTENT:

- SKILL:	Constructing a model. (E-5)
- KNOWLEDGE:	Concept of an atom, characteristics of a good model. (A-9)
- ATTITUDE:	Critical attitude. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Brainstorming, group work, class discussion.
B. DURATION: (125/150) minutes.
C. EVALUATION: Congruence of the student's model with experimental results.
D. MATERIALS: Different coloured styrofoam spheres, wire.
E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

SHAPIRO, B. and SHAPIRO, S. **Chemistry at Work.** Mississauga, Ont.: Copp Clark Pitman, 1989, pp. 70-87.

Video: **Introducing Chemistry - Types of Chemical Change**, 14 min, Coronet.

LEARNING ACTIVITIES

THE STUDENT:

4.2.1 Devises a way of representing the smallest component of each of the pure substances examined in 3.3 and 3.4.

4.2.2 Represents the chemical change in 3.3, using the objects he/she has selected in 4.2.1.

4.2.3 Verifies whether his/her model of a chemical change accounts for the change in the mass of the substance.

4.2.4 Predicts the decomposition of the pure substance on the basis of the model suggested in 4.2.2.

4.2.5 Verifies whether his/her model is consistent with his/her observations regarding the chemical changes in 3.3 and 3.4.

4.2.6 Identifies the criteria of a good model.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and intermediate)

THE STUDENT WILL BE ABLE TO:

4.3 Analyze Dalton's atomic model.

PREREQUISITES:

4.2

RELATED CONTENT:

-	SKILL:	Constructing a model. (E-5)
-	KNOWLEDGE:	Solubility of gases in liquids. Dalton's atomic model. (A-9)
-	ATTITUDE:	"Constructivist" view of science. (I-2)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Individual work, class discussion, demonstration.
B. DURATION: (50/75) minutes in class + work at home.
C. EVALUATION: Student's description.
D. MATERIALS: Reference materials, soft drink.
E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

Educational Software: **Chemistry, vol. 1**, Arrakis Technologies, Montréal.
Videos: **CONCEPTS IN SCIENCE SERIES,** TV Ontario, Tape 9 - **Structure of the Atom,** two 10-minute programs:
1. The Earliest Models;
2. Smaller than the Smallest.

LEARNING ACTIVITIES

THE STUDENT:

4.3.1 Becomes aware of Dalton's atomic model.

4.3.2 Becomes aware of the property of matter that served as the basis for Dalton's atomic model.

4.3.3 Compares Dalton's model with those of Democritus and Aristotle.

4.3.4 Assesses Dalton's model, based on the criteria of a good model (4.2.6).

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

4.4 Demonstrate that matter contains two types of electric charges, after doing experiments and documentary research.

PREREQUISITES:

4.3

RELATED CONTENT:

- SKILL: Interpreting data. (D-3)
- KNOWLEDGE: Electric charges and their behaviour. (A-3)
- ATTITUDE: "Constructivist" view of science. (I-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Group work, laboratory work, class discussion.
B. DURATION: (175/200) minutes in class + work at home.
C. EVALUATION: Student's demonstration.
D. MATERIALS: Strips of vinylite, strips of cellulose acetate, pieces of wool and cotton, ring stand, ring, thread, reference materials.
E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

DONOVAN, T.; POOLE, M. and YACK, D. **Chemicals in Action.** Toronto: Holt, Rinehart and Winston of Canada Limited, 1987, pp. 77-81.
Educational Software: **Structure of Matter**, TECHBYTE.
Videos:
- **Electric Interactions in Chemistry,** 21 min, Ward's Natural Science Establishment.
- **ELECTRICITY SERIES,** TV Ontario, two 10-minute programs: **Charging and Discharging; Charging by Induction.**

LEARNING ACTIVITIES

THE STUDENT:

4.4.1 Identifies examples of static electricity in the environment.

4.4.2 Formulates a hypothesis that explains the observed phenomenon.

4.4.3 Produces an electric charge in various objects through friction by following a suggested experimental procedure.

4.4.4 Describes how small objects (e.g. plastic strip, pieces of paper) behave when they are placed near a charged object.

4.4.5 Carries out an experiment with different types of objects by following a suggested procedure.

4.4.6 Describes how charged objects behave when they are brought close together.

4.4.7 Tabulates the results of the experiment.

4.4.8 Identifies objects that behave in the same way.

4.4.9 Modifies the hypothesis formulated in 4.4.2 to account for the new phenomena observed.

4.4.10 Compares his/her hypothesis with those of the other students.

4.4.11 Compares his/her hypothesis with the one generally accepted.

4.4.12 Describes the chronological development of the hypotheses of scientists.

4.4.13 Describes the impact of these discoveries on the lives of the people at that time.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

4.5 Demonstrate that matter contains negative charges, based on the properties of cathode rays.

PREREQUISITES:

4.4

RELATED CONTENT:

- SKILL: Observing. (B-2)
- KNOWLEDGE: Properties of cathode rays, direction of electric current. (A-1)
- ATTITUDE: Intellectual curiosity. (H-5)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY: Demonstration, group work, class discussion.

B. DURATION: (75/100) minutes in class + work at home.

C. EVALUATION: Student's understanding of the properties of cathode rays.

D. MATERIALS: Cathode ray tubes, power supply, magnets, reference materials.

E. SAFETY MEASURES: Cathode ray tubes, high voltage.

SUGGESTED REFERENCES:

16 mm film and video: **Les écrans cathodiques**, 21 min, Radio-Canada.

*Video: **CONCEPTS IN SCIENCE SERIES,** TV Ontario, Tape 9 - **Structure of the Atom,** one 10-minute program: **2. Smaller than the Smallest.**

LEARNING ACTIVITIES

THE STUDENT:

4.5.0 Recalls the rule regarding the direction of electric current (I.T.T. 314).

4.5.1 Observes the behaviour of cathode rays in a discharge tube.

4.5.2 Formulates hypotheses that explain the behaviour observed.

4.5.3 Compares his/her hypotheses with those of scientists, after consulting suggested reference materials.

4.5.4 Reformulates his/her hypotheses, if necessary.

4.5.5 Examines Dalton's model critically, taking into consideration the new information.

4.5.6 Describes the impact of the discovery of cathode rays on the understanding of the properties and structure of matter.

4.5.7 Illustrates the economic and social importance of the current use of cathode rays.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

*4.5 Demonstrate that matter contains positive and negative charges, based on the properties of radioactive substances.

PREREQUISITES:

RELATED CONTENT:

-	SKILL:	Generalizing. (2-6)
-	KNOWLEDGE:	Radioactivity, positive and negative charges in matter. (4-[illegible])
-	ATTITUDE:	Willingness to compare ideas. (4-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Demonstration, individual work, class discussion.

B. DURATION:	60 minutes in class + work at home.
C. EVALUATION:	Student's description.
D. MATERIALS:	Radioactive material, cloud chamber (Wilson chamber), reference materials.
E. SAFETY MEASURES:	Radioactivity, dry ice.

SUGGESTED REFERENCES:

DORIN, H. **Chemistry: The Study of Matter.** Fairfield, N.J.: Cebeco Standard Publishing, 1982, pp. 187-190.

*Videos: **CONCEPTS IN SCIENCE SERIES,** TV Ontario. Tape 8 - **Nuclear Physics,** a series of six 10-minute programs: 1. **The Discovery of Radioactivity;** 2. **Properties of Becquerel Rays;** 3. **Natural Transmutations;** 4. **Energy from the Nucleus;** 5. **Electrical Energy from Fission;** 6. **Nuclear By-Products.**

CONCEPTS IN SCIENCE SERIES, TV Ontario. Tape 9 - **Structure of the Atom,** one 10-minute program: 3. **The Rutherford Model.**

LEARNING ACTIVITIES

THE STUDENT:

4.5.1 Describes how Becquerel discovered radioactivity.

4.5.2 Observes the behaviour of alpha, beta, and gamma rays, using [illegible] methods.

4.5.3 Explains the behaviour of these rays on the basis of electrical charges.

4.5.4 Compares his/her explanations with those of scientists, after consulting suggested reference materials.

4.5.5 Reformulates his/her explanations, if necessary.

4.5.6 Describes the impact of the discovery of radioactivity on the understanding of the properties and structure of matter.

4.5.7 Describes the contributions of Marie Sklodowska-Curie and Pierre Curie to the use of radioactive substances.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

*4.7 Analyze Thomson's atomic model.

PREREQUISITES:

4.3, 4.4, 4.5, 4.6

RELATED CONTENT:

- SKILL: Constructing a model. (E-4)
- KNOWLEDGE: Thomson's atomic model. (A-9)
- ATTITUDE: "Constructivist" view of science. (I-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Group work, individual work, class discussion.
B. DURATION: 60 minutes in class + work at home.
C. EVALUATION: Student's new hypotheses.
D. MATERIALS: Reference materials.
E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

Film Loop: **Thomson's Atomic Model**, 4 min, N.F.B.

LEARNING ACTIVITIES

THE STUDENT:

4.7.1 Suggests an atomic model that takes into account previous experiments and observations, based on Dalton's atomic model.

4.7.2 Compares his/her model with Thomson's model, after consulting suggested reference materials.

4.7.3 Modifies his/her model, if necessary.

4.7.4 Describes the scientific impact of Thomson's model on the understanding of the properties and structure of matter.

4.7.5 Assesses Thomson's atomic model based on the criteria of a good model (4.2.6), taking into account the new phenomena observed (4.4, 4.5, 4.6).

4.7.6 Identifies currently known phenomena that are not explained by Thomson's model.

4.7.7 Suggests modifications to Thomson's model that could account for these phenomena.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

***4.8 Analyze** Rutherford's atomic model.

PREREQUISITES:

4.7

RELATED CONTENT:

- SKILL:	Constructing a model. (E-3)
- KNOWLEDGE:	Rutherford's atomic model. (A-9)
- ATTITUDE:	"Constructivist" view of science. (I-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Simulation, group work, individual work, class discussion.

B. DURATION:	100 minutes in class + work at home.
C. EVALUATION:	Student's model.
D. **MATERIALS:**	Marbles, objects of any geometric shape, reference materials.
E. SAFETY MEASURES:	None.

SUGGESTED REFERENCES:

HINDIN, Wendy B. "Rutherford Experiment - An Analogy." **Idea Bank Collection.** #195, Vol. 1, Queen's University, Kingston, Ont.

Film Loop: **Dispersion de Rutherford**, 4 min, N.F.B.

*Video: **CONCEPTS IN SCIENCE SERIES,** TV Ontario, Tape 9 - **Structure of the Atom,** one 10-minute program:4. **The Bohr Model.**

LEARNING ACTIVITIES

THE STUDENT:

4.8.1 Simulates Rutherford's experiment.

4.8.2 Describes Rutherford's experiment on the behaviour of alpha particles shot at gold foil.

4.8.3 Verifies whether Thompson's model can explain the results of Rutherford's experiment.

4.8.4 Suggests an atomic model that takes into account the results of Rutherford's experiment, based on Thomson's model.

4.8.5 Compares his/her model with Rutherford's model, after consulting suggested reference materials.

4.8.6 Modifies his/her model, if necessary.

4.8.7 Describes the scientific impact of Rutherford's model on the understanding of the properties and structure of matter.

4.8.8 Assesses Rutherford's model based on of the criteria of a good model (4.2.6).

4.8.9 Identifies currently known phenomena that are not explained by Rutherford's model.

4.8.10 Suggests modifications to Rutherford's model that could account for these phenomena.

4.8.11 Explains the place of Rutherford's work in the history of scientific research in Québec.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and intermediate)

THE STUDENT WILL BE ABLE TO:

4.9 **Describe the simplified atomic model currently in use (Rutherford-Bohr).**

PREREQUISITES:

4.8

RELATED CONTENT:

- SKILL: Constructing a model. (E-6)
- KNOWLEDGE: Rutherford-Bohr atomic model. (A-9)
- ATTITUDE: "Constructivist" view of science. (I-2)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Presentation, individual work, class discussion.
B. DURATION: (125/150) minutes in class + work at home.
C. EVALUATION: Sudent's knowledge of simplified atomic model currently in use.
D. MATERIALS: Reference materials.
E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

*Videos:
- **CONCEPTS IN SCIENCE SERIES**, TV Ontario, Tape 9 - **Structure of the Atom**, four 10-minute programs: **3. The Rutherford Model; 4. The Bohr Model; 5. Spectra; 6. The Wave-Mechanical Model.**
- **CONCEPTS IN SCIENCE SERIES**, TV Ontario, Tape 5 - **Electron Arrangement and Bonding**, one 10-minute program: 3. **Electron Arrangement.**

LEARNING ACTIVITIES

THE STUDENT:

4.9.1 Becomes aware of Rutherford's representation of a proton (nucleus of a hydrogen atom).

4.9.2 Becomes aware of Chadwick's representation of a neutron.

4.9.3 Becomes aware of Neils Bohr's representation of electron arrangement by energy level.

4.9.4 Associates the atomic number of an element with the number of protons in its nucleus.

4.9.5 Associates the number of electrons in a neutral element with the number of protons in its nucleus.

4.9.6 Suggests an atomic model that takes into account protons, neutrons, and electron energy levels, based on the Rutherford-Bohr atomic model.

4.9.7 Compares his/her model with the simplified atomic model currently in use, after consulting suggested reference materials.

4.9.8 Assesses the simplified atomic model currently in use, based on the criteria of a good model (4.2.6).

4.9.9 Suggests hypotheses that could improve on the simplified atomic model currently in use, based on the most recent findings.

4.9.10 Becomes aware of the fact that knowledge is often constructed as result of teamwork.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

5. **Analyze the periodic table, based on the properties of matter he/she has examined while doing scientific work and on an atomic model with which he/she has become familiar.**

5.1 Describe the progression of the atomic masses of the elements in the periodic table.

PREREQUISITES:

4.9

RELATED CONTENT:

- SKILL: Interpreting data. (D-3)
- KNOWLEDGE: Atomic mass. (A-5)
- ATTITUDE: Willingness to interpret information. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Presentation, group work, individual work, class discussion.
B. DURATION: (50/75) minutes.
C. EVALUATION: Student's hypotheses.
D. MATERIALS: Periodic table.
E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

DORIN, H. **Chemistry: The Study of Matter.** Fairfield, N.J.: Cebeco Standard Publishing, 1982, pp. 228-232.

LEARNING ACTIVITIES

THE STUDENT:

5.1.1 Becomes aware of the definition of atomic mass.

5.1.2 Compares the atomic masses of all the elements in the periodic table.

5.1.3 Discovers how atomic masses of elements vary in the periodic table.

5.1.4 Formulates hypotheses that explain this progression.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and intermediate)

THE STUDENT WILL BE ABLE TO:

5.2 Identify the advantages and disadvantages of using isotopes in industry, medical science, basic research, and in the environment.

PREREQUISITES:

5.1

RELATED CONTENT:

- SKILL: Generalizing. (F-3)
- KNOWLEDGE: Advantages and disadvantages of using isotopes. (A-10)
- ATTITUDE: Willingness to synthesize and apply knowledge.(I-4)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Brainstorming, group work, individual work, class discussion.
B. DURATION: (50/75) minutes in class + work at home.
C. EVALUATION: Student's knowledge of the use of isotopes.
D. MATERIALS: Reference materials.
E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

Videos: - **Atomic Energy of Canada**, 27 min, N.F.B.
- **Isotopes in Action**, 28 min, N.F.B.

LEARNING ACTIVITIES

THE STUDENT:

5.2.1 Describes his/her concept of an isotope.

5.2.2 Becomes aware of the definition of an isotope.

5.2.3 Distinguishes between natural and artificial isotopes.

5.2.4 Describes a way of producing artificial isotopes.

5.2.5 Identifies the advantages and disadvantages of using radioactive substances.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

*5.3 Analyze the irregularities in the progression of the atomic masses of the elements in the periodic table.

PREREQUISITES:

5.1, 5.2

RELATED CONTENT:

-	**SKILL:**	Interpreting data. (D-3)
-	**KNOWLEDGE:**	Fractional atomic mass. (A-5)
-	**ATTITUDE:**	Willingenss to interpret information. (H-3)

SUGGESTED TEACHING PLAN:

A. **TEACHING STRATEGY:**
Group work, class discussion.

B.	**DURATION:**	60 minutes.
C.	**EVALUATION:**	Student's argumentation.
D.	**MATERIALS:**	Periodic table, reference manual.
E.	**SAFETY MEASURES:**	None.

SUGGESTED REFERENCES:

DORIN, H. **Chemistry: The Study of Matter.** Fairfield, N.J.: Cebeco Standard Publishing, 1982, pp. 230-232.

LEARNING ACTIVITIES

THE STUDENT:

5.3.1 Formulates hypotheses to explain fractional atomic masses of the elements in the periodic table.

5.3.2 Identifies irregularities in the progression of the atomic masses of the elements in the periodic table.

5.3.3 Formulates hypotheses to explain these irregularities.

5.3.4 Becomes aware of the relative abundance of isotopes of certain elements.

5.3.5 Calculates the atomic mass of certain elements, based on the relative abundance of their isotopes.

5.3.6 Justifies these irregularities.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

5.4 Locate metals, non-metals, and metalloids in the periodic table.

PREREQUISITES:

2.1, 2.2, 2.3

RELATED CONTENT:

- SKILL:	Organizing data. (D-2)
- KNOWLEDGE:	Characteristic properties of metals, non-metals, and metalloids; names and symbols of the elements. (A-6)
- ATTITUDE:	Intellectual curiosity. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY: individual work, laboratory work, demonstration, class discussion.

B. DURATION:	(75/100) minutes in class + work at home.
C. EVALUATION:	Student's understanding of the characteristic properties of metals, non-metals, and metalloids.
D. MATERIALS:	HCl (diluted), conducting wire, light bulb, battery, mortar and pestle or hammer and ring stand base, emery paper, steel plate, (object that serves as an anvil).
Substances:	Al, Fe, Cu, W, Mg, C, Si, S, O_2, N_2, He.
E. SAFETY MEASURES:	Hammering of elements, measures to protect the environment.

SUGGESTED REFERENCES:

Educational Software:	**Chemistry: The Elements**, ComPress, Wenworth, NH 03282.
16 mm Film:	**Chemical Families**, 22 min, Ward's Natural Science Establishment.

LEARNING ACTIVITIES

THE STUDENT:

5.4.0 Recalls the characteristic properties of matter (T.0.2).

5.4.1 Divides elements into three categories after observing certain properties (lustre, thermal and electrical conductivity, malleability, reaction when combined with an acid).

5.4.2 Identifies, by their symbols, the principal elements of each category.

5.4.3 Locates each of these categories of elements on the periodic table.

5.4.4 States the meaning of the heavy stair-step line found in some periodic tables.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and intermediate)

THE STUDENT WILL BE ABLE TO:

5.5 Locate the family of alkali metals, alkaline earth metals, halogens, and inert gases on the periodic table.

PREREQUISITES:

5.4

RELATED CONTENT:

- SKILL: Interpreting data. (D-3)
- KNOWLEDGE: Properties of alkali metals, alkaline earth metals, halogens, inert gases, families of elements. (A-6)
- ATTITUDE: Willingness to interpret information. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Demonstration, group work, laboratory work, class discussion.
B. DURATION: (100/125) minutes.
C. EVALUATION: Student's ability to locate families on the periodic table.
D. MATERIALS: 1 000 mL beakers, 13 mm x 100 mm test tubes, stoppers.
Substances: Na, K, H_2O, phenolphtalein, chlorine water, bromine water, aqueous solution of NaI (0.1 mol/L), tincture of iodine (aqueous solution of iodine and alcohol), cyclohexane.
E. SAFETY MEASURES: Proper handling and disposal of chemicals, measures to protect the environment.

SUGGESTED REFERENCES:

Film Loop: **Alkali Metal Reaction with Chlorine**, 4 min, Ward's Natural Science Establishment.
16 mm Film: **Chemical Families**, 22 min, Ward's Natural Science Establishment.

LEARNING ACTIVITIES

THE STUDENT:

5.5.1 Observes some of the chemical properties of given elements, using appropriate methods.

5.5.2 Associates similar applications with elements of a particular family.

5.5.3 Divides these elements into four families, based on the chemical properties observed.

5.5.4 Locates these families on the periodic table.

5.5.5 Identifies, by their symbols, the elements belonging to the same family.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and intermediate)

THE STUDENT WILL BE ABLE TO:

*5.6 Describe the progression of certain properties of elements in a given period on the basis of their atomic number.

PREREQUISITES:

2.1, 2.2, 2.3, 5.1

RELATED CONTENT:

- SKILL: Organizing data. (D-2)
- KNOWLEDGE: Period, progression of properties within a period. (A-5)
- ATTITUDE: Conscientiousness. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Group work, individual work, class discussion.
B. DURATION: 140 minutes in class + work at home.
C. EVALUATION: Student's interpretation of graphs.
D. MATERIALS: Periodic table, reference manual, graph paper.
E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

Educational Software: **Periodic Table of the Elements**, Big Blue Disk, N° 31, Softdisk Inc., Shreveport, LA 71130-0008.

16 mm Film: **Chemical Families**, 22 min, Ward's Natural Science Establishment.

LEARNING ACTIVITIES

THE STUDENT:

5.6.1 Becomes aware of the atomic number of each element in the periodic table.

5.6.2 Draws, for the first 36 elements of the periodic table, one or two graphs showing the relationship between atomic number and the value of a particular property (e.g. density, melting point, boiling point, electrical conductivity, thermal conductivity or atomic radius).

5.6.3 Studies three or four graphs showing the relationship between atomic number and the values of other properties for all the elements in the periodic table.

5.6.4 Locates on the graphs the elements of the same period.

5.6.5 Determines the trend of each property within that period.

5.6.6 Predicts the unknown property of an element on the basis of how this property changes from element to element in that period.

5.6.7 Lists the technological applications of some representative elements of each of the periods.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

**5.7 Describe the progression of certain properties of elements of a particular family as a function of their atomic number.

PREREQUISITES:

2.1, 2.2, 5.4, 5.6

RELATED CONTENT:

- SKILL: Interpreting data. (D-4)
- KNOWLEDGE: Progression of properties within a period, technological applications. (A-5)
- ATTITUDE: Willingness to interpret information. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Group work, class discussion.
B. DURATION: (75/100) minutes.
C. EVALUATION: Student's interpretation of graphs.
D. MATERIALS: Periodic table, graphs used in 5.6.
E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

16 mm Film: **Chemical Families**, 22 min, Ward's Natural Science Establishment.

LEARNING ACTIVITIES

THE STUDENT:

5.7.1 Locates on the graphs drawn in 5.6.2 and on the graphs examined in 5.6.3 the elements of a particular family.

5.7.2 Compares some of the properties of the elements of the same family.

5.7.3 Discovers the trends in the properties of the elements of the same family.

5.7.4 Lists the technological applications of some of the representative elements of each family studied in 5.5.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

5.8 Justify the classification of alkali metals, alkaline earth metals, halogens, and inert gases in the periodic table on the basis of the simplified atomic model currently in use.

PREREQUISITES:

4.9, 5.5

RELATED CONTENT:

- SKILL: Interpreting data. (D-3)
- KNOWLEDGE: Simplified atomic model currently in use (Rutherford-Bohr), structure of the periodic table, valence electrons, chemical stability. (A-6)
- ATTITUDE: Willingness to interpret information. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY: Group work, class discussion.
B. DURATION: (50/75) minutes.
C. EVALUATION: Student's knowledge of valence electrons.
D. MATERIALS: Periodic table.
E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

Educational Software: **Chemistry vol. 2**, Arrakis Technologies Montréal.

METCALFE, H; WILLIAMS, J.; and CASTKA, J. **Modern Chemistry.** Toronto: Holt, Rinehart and Winston of Canada Limited, 1986, The Metals of Group I, p. 565; The Metals of Group II, p. 579; Nitrogen, p. 631; Sulfur, p. 643; The Halogen Family, p. 655.

LEARNING ACTIVITIES

THE STUDENT:

5.8.1 Associates similar chemical properties of elements of the same family with the number of electrons in their outer level (valence electrons).

5.8.2 Associates the group number of each representative element with the number of valence electrons it has.

5.8.3 Associates the tendency for electron stability with the octet structure of family 8.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and intermediate)

THE STUDENT WILL BE ABLE TO:

5.9 Justify the structure of the periodic table on the basis of the simplified atomic model currently in use.

PREREQUISITES:

2.1, 2.2, 4.9, 5.6, 5.8

RELATED CONTENT:

- SKILL: Constructing a model. (E-5)
- KNOWLEDGE: Electron levels. (A-11)
- ATTITUDE: Willingness to clarify a problem. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Group work, class discussion.
B. DURATION: (50/75) minutes.
C. EVALUATION: Student's justification.
D. MATERIALS: Periodic table.
E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

DONOVAN, T.; POOLE, M.; and YACK, D. **Chemicals in Action.** Toronto: Holt, Rinehart and Winston of Canada Limited, 1987, pp. 125-129.

LEARNING ACTIVITIES

THE STUDENT:

5.9.0 Recalls the simplified atomic model currently in use (4.9).

5.9.1 Determines the maximum number of electrons per orbit in the first three energy levels.

5.9.2 Determines the number of electrons in the following elements: He, Ne, and Ar.

5.9.3 Determines the number of electron energy levels in each element in 5.9.2.

5.9.4 Associates the number of electron energy levels in each of these elements with the number of the period to which they belong in the periodic table.

5.9.5 Draws the atomic structure of the first 18 elements in the periodic table, based on the simplified atomic model currently in use.

5.9.6 Draws the atomic structure of elements 19 and 20 and, if necessary, the atomic structure of the subsequent elements based on the simplified atomic model currently in use.

5.9.7 Compares the drawing of the structure of element 21 and, if necessary, of the structure of the subsequent elements with the scientists' conceptions of these elements.

5.9.8 Re-assesses the simplified atomic model currently in use based on the criteria of a good model.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and intermediate)

THE STUDENT WILL BE ABLE TO:

**5.10 Trace the history of the development of the periodic table by consulting reference materials.

PREREQUISITES:

5.1, 5.5

RELATED CONTENT:

- SKILL: Generalizing. (F-1)
- KNOWLEDGE: History of the development of the periodic table. (A-10)
- ATTITUDE: "Constructivist" view of science. (I-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Individual work, class discussion.
B. DURATION: (75/125) minutes in class + work at home.
C. EVALUATION: Student's report.
D. MATERIALS: Reference materials.
E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

FAVARO, T. "Periodic Table of Elements, Student Construction." **Idea Bank Collation**, #559, Vol 1. Queen's University, Kingston, Ont.

LEARNING ACTIVITIES

THE STUDENT:

5.10.1 Identifies the principal scientists who contributed to the development of the current periodic table.

5.10.2 Discovers Mendeleev's contribution.

5.10.3 Shows how the development of Mendeleev's law was linked to a gradual understanding of atomic structure.

5.10.4 Discovers the impact of the periodic table on the understanding of the properties of matter.

5.10.5 Discovers how the periodic table has influenced the search for new elements.

5.10.6 States the origin of the names of the elements.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and intermediate)

THE STUDENT WILL BE ABLE TO:

6. **Represent the molecule of a pure substance, using a model that takes into account the properties of matter, an atomic model, and the classification of elements he/she has examined while doing scientific work.**

6.1 Illustrate the structure of a water molecule, after conducting a laboratory experiment in accordance with the suggested procedure.

PREREQUISITES:

3.2, 3.3, 3.4

RELATED CONTENT:

- SKILL: Observing. (G-2)
- KNOWLEDGE: Molecular formula. (A-7)
  ATTITUDE: Sense of responsibility (concern for health and safety). (G-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Laboratory work, class discussion.
B. DURATION: (100/125) minutes.
C. EVALUATION: Student's laboratory work.
D. MATERIALS: Ring stand, stoppers, burette clamps, grad- uated tubes, beakers, carbon, electrodes, power supply, stirring rods, wooden splints, matches, H_2SO_4 (1 mol/L), distilled water.
E. SAFETY MEASURES: Danger of exploding hydrogen, corrosive substances.

SUGGESTED REFERENCES:

LEARNING ACTIVITIES

THE STUDENT:

6.1.0 Recalls the model of matter (4.2).

Recalls the two types of charges (4.4).

Recalls the rule regarding the direction of the electric current (I.T.T. 314).

6.1.1 Describes his/her conception of a molecule.

6.1.2 Carries out the electrolysis of acidulated water by following the suggested procedure.

6.1.3 Compares the volumes of the gases produced.

6.1.4 Suggests an explanation for the magnitude of the volumes of the gases produced.

6.1.5 Determines the properties of the gases produced.

6.1.6 Identifies the gases produced.

6.1.7 Suggests an explanation for the formation of a different product at each electrode.

6.1.8 Compares his explanation with those of the other students.

6.1.9 Concludes that electrolysis brings about a chemical change.

6.1.10 Suggests a model for a water molecule, using the symbols for its constituent elements.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

*6.2 Verify the molecular formula for water by referring to the periodic table.

PREREQUISITES:

5.8, 5.9, 6.1

RELATED CONTENT:

- SKILL:	Interpreting data. (D-3)
- KNOWLEDGE:	Relationships among groups of elements in the periodic table, molecular formulas. (A-6)
- ATTITUDE:	Intellectual curiosity. (H-4)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Group work, class discussion.

B. DURATION:	90 minutes.
C. EVALUATION:	Student's ability to apply the octet rule.
D. MATERIALS:	Periodic table, reference materials.
E. SAFETY MEASURES:	None.

SUGGESTED REFERENCES:

DAGONET, François. **Tableaux et langage de la chimie,** Paris, Seuil, 1980, (Collection Science ouverte).

LEARNING ACTIVITIES

THE STUDENT:

6.2.0 Recalls the concept of the chemical stability of elements (5.9).

6.2.1 Associates the group number of hydrogen with the number of bonds that this element can form.

6.2.2 Associates the number of bonds that oxygen can form with the difference between 8 and its group number.

6.2.3 Justifies the model of a water molecule suggested in 6.1.10.

6.2.4 Verifies whether the octet rule applies to other groups of elements in the periodic table.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

*6.3 Write the molecular formula of substances composed of two types of elements, based on the group numbers of the representative elements of the periodic table.

PREREQUISITES:

6.2

RELATED CONTENT:

-	SKILL:	Generalizing. (D-6)
-	KNOWLEDGE:	Groups in the periodic table, molecular formulas, metals, non-metals. (A-10)
-	ATTITUDE:	Willingness to synthesize and apply knowledge. (I-1)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Group work, class discussion.
B. DURATION: 90 minutes.
C. EVALUATION: Student's formula.
D. MATERIALS: Periodic table.
E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

DORIN, H. **Chemistry: The Study of Matter.** Fairfield, N.J.: Cebeco Standard Publishing, 1982, pp. 252-257.

LEARNING ACTIVITIES

THE STUDENT:

6.3.1 Associates the group number of a metal with the number of bonds that this element can form.

6.3.2 Associates the number of bonds that a non-metal can form with the difference between 8 and its group number.

6.3.3 Predicts the molecular formula of substances composed of a metal and a non-metal.

6.3.4 Suggests a molecular formula for a compound consisting of only two non-metals.

6.3.5 Concludes that there may be some exceptions to a rule.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

6.4 Illustrate the structure of the molecule of a pure substance, given its chemical name.

PREREQUISITES:

3.3, 6.1

RELATED CONTENT:

- SKILL: Communicating. (F-4)
- KNOWLEDGE: Rules of nomenclature, rules for writing formulas. (A-4)
- ATTITUDE: Concern for the use of correct language. (F-4)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Presentation, group work, individual work, class discussion.
B. DURATION: (50/75) minutes in class + work at home.
C. EVALUATION: Student's ability to apply the rules of nomenclature and rules for writing formulas.
D. MATERIALS: Reference materials.
E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

METCALFE, H.; WILLIAMS, J. and CASTKA, J. **Modern Chemistry.** Toronto: Holt, Rinehart and Winston of Canada Limited, 1986, p.117.

LEARNING ACTIVITIES

THE STUDENT:

6.4.1 Becomes aware of the rules of nomenclature concerning the numerical prefixes used to name substances consisting of two types of elements.

6.4.2 Becomes aware of the rules for writing molecular formulas to represent the composition of substances consisting of two types of elements.

6.4.3 Names substances consisting of two types of elements, based on their molecular formula.

6.4.4 Writes the molecular formula of a substance, based on its name.

6.4.5 Lists a number of commonly used domestic food items, and pharmaceutical or industrial products.

6.4.6 Names the chemical substances contained in the products listed in 6.4.5 by referring to their labels.

6.4.7 Identifies the scientific name of common chemicals that have a commercial brand name, using a reference manual.

6.4.8 Writes the molecular formula of chemical substances, using a reference manual if necessary.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

**6.5 Illustrate the molecule of a pure substance, using the Lewis method of representing the structure of matter.

PREREQUISITES:

3.3, 5.5, 6.2, 6.3

RELATED CONTENT:

-	SKILL:	Generalizing. (E-6)
-	KNOWLEDGE:	Lewis method of representing the structure of matter. (A-4)
-	ATTITUDE:	Intellectual curiosity. (a-2)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Presentation, group work, individual work, class discussion.

B. DURATION: (50/75) minutes.

C. EVALUATION: Student's understanding of the Lewis method of representing the structure of matter.

D. MATERIALS: Periodic table.

E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

Educational Software: **Chemistry: Lewis Diagrams**, ComPress, Wenworth, NH 03282.

LEARNING ACTIVITIES

THE STUDENT:

6.5.1 Becomes aware of the Lewis method of representing the structure of matter.

6.5.2 Draws the structure of particles (H, H_2, N, N_2, O, O_2, Cl, Cl_2, P,P_4, S, S_8), using the Lewis method of representing the structure of matter.

6.5.3 Draws the structure of compounds (H_2O, HCl, NH_3, CH_4, $NaCl$, KI, MgO), using the Lewis method of representing the structure of matter.

6.5.4 Lists the advantages of the Lewis method of representing the structure of matter.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

**6.6 Illustrate the composition of a pure substance, using its structural formula.

PREREQUISITES:

3.3, 5.8, 6.2, 6.3, 6.5

RELATED CONTENT:

- SKILL: Constructing a model. (E-5)
- KNOWLEDGE: Structural formula of a pure substance. (A-4)
- ATTITUDE: Creative approach. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Group work, individual work, class discussion.
B. DURATION: (50/75) minutes.
C. EVALUATION: Student's understanding of structural formulas.
D. MATERIALS: Periodic table.
E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

METCALFE, H.; WILLIAMS, J. and CASTKA, J. **Modern Chemistry.** Toronto: Holt, Rinehart and Winston of Canada Limited, 1986. Section on Lewis Structure, p. 275.

LEARNING ACTIVITIES

THE STUDENT:

6.6.1 Writes the molecular formula of the elements and the compounds examined in 6.5.

6.6.2 Draws the structural formula of the elements and compounds examined in 6.5.

6.6.3 Lists and compares the advantages and disadvantages of a structural formula with those of the Lewis method of representing the structure of matter.

6.6.4 Devises another way of representing the composition of a pure substance.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and intermediate)

THE STUDENT WILL BE ABLE TO:

**6.7 Represent the molecular structure of a pure substance, using dimensional models.

PREREQUISITES:

3.3, 6.2, 6.3, 6.5, 6.6

RELATED CONTENT:

-	SKILL:	Constructing a model. (E-6)
-	KNOWLEDGE:	Molecules of elements, molecules of compounds, dimensional molecular models. (A-11)
-	ATTITUDE:	Self-confidence. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Group work, class discussion.
B. DURATION: (50/75) minutes.
C. EVALUATION: Student's perseverance.
D. MATERIALS: Molecular model set.
E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

TURNER, A. and SEARS, C. **Inquiries in Chemistry.** Toronto: Allyn and Bacon Canada Ltd., 1977, p. 73.

LEARNING ACTIVITIES

THE STUDENT:

6.7.1 Constructs representations of the molecular structure of certain elements (H_2, N_2, O_2, P_4, S_8), using three-dimensional models.

6.7.2 Constructs representations of the molecular structure of certain compounds (HCl, H_2O, NH_3, CH_4, NaCl, KI, MgO), using dimensional models.

6.7.3 Compares the advantages and disadvantages of dimensional representations with those of the Lewis method of representing the structure of matter.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and intermediate)

THE STUDENT WILL BE ABLE TO:

**6.8 Write a chemical equation to represent the electrolysis and synthesis of water.

PREREQUISITES:

6.1, 6.5, 6.6, 6.7

RELATED CONTENT:

- SKILL: Communicating. (F-4)
- KNOWLEDGE: Chemical equations. (A-11)
- ATTITUDE: Creative approach. (H-3)

LEARNING ACTIVITIES

THE STUDENT:

6.8.1 Becomes aware of what a chemical equation is.

6.8.2 Suggests a chemical equation that represents the electrolysis of water.

6.8.3 Suggests a chemical equation that represents the synthesis of water.

6.8.4 Devises a way of writing a single equation to represent the electrolysis and synthesis of water.

6.8.5 Illustrates the synthesis of water, using the Lewis method of representing the structure of matter.

E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

DORIN, H. **Chemistry: The Study of Matter.**
Fairfield, N.J.: Cebeco Standard Publishing.
1982, pp. 268-274.

LEDBETTER, E. and YOUNG, J. **Keys to Chemistry.**
Addison-Wesley Publishing, 1977, p. 214.

Module 11
Electrical Phenomena

MODULE OBJECTIVE: TO EXPLORE the electrical properties of matter as well as the ways in which the production, transformation, and use of electric energy affect the environment and the lives of Quebecers, using the scientific method.

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

1. **Measure at least one of the variables associated with electric circuits, using an instrument that he/she has constructed.**

   1.1 Determine the measuring instrument that he/she will construct.

PREREQUISITES:

Module 1-1

RELATED CONTENT:

- SKILL: Developing a procedure. (C-4)
- KNOWLEDGE: Variables associated with electric circuits. (A-7)
- ATTITUDE: Intellectual curiosity. (H-5)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Presentation, brainstorming, class discussion, individual work.
B. DURATION: (50/50) minutes.
C. EVALUATION: Student's procedure for constructing an instrument.
D. MATERIALS: Reference materials.
E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

Video: **Les appareils de mesures**, 11 min, Multi-média Audiovisuel Inc., Montréal.

LEARNING ACTIVITIES

THE STUDENT:

1.1.0 Recalls the steps involved in organizing and carrying out a research project (Module 1-1).

1.1.1 Discusses the concept of scientific measurement.

1.1.2 Identifies the variable(s) to be measured.

1.1.3 Describes the instrument needed to measure the selected variable(s).

1.1.4 Suggests a procedure for constructing the measuring instrument.

1.1.5 Has this procedure approved.

List of Possible Measuring Instruments for This Project
1- Electroscope
2- Galvanometer
3- Ammeter
4- Voltmeter
5- Ohmmeter
6- Multimeter
7- Wattmeter
8- Joulemeter
9- Magnetic field detector (compass)
10- Current Balance
11- Thermocouple (thermometer)
12- Electric Pyrometer
13- Photometer
14- ...

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

1.2 Draw a curcuit diagram of the measuring instrument he/she will construct, using conventional symbols.

PREREQUISITES:

1.1

RELATED CONTENT:

- SKILL: Communicating. (F-4)
- KNOWLEDGE: Conventional symbols used in circuit diagrams. (A-4)
- ATTITUDE: Conscientiousness. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Individual work, meetings between the teacher and each student.
B. DURATION: (75/75) minutes in class + work at home.
C. EVALUATION: Circuit diagrams.
D. MATERIALS: Reference materials, technical drawing instruments.
E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

LEARNING ACTIVITIES

THE STUDENT:

1.2.1 Identifies the different components used to construct his/her measuring instrument.

1.2.2 Associates a conventional symbol with each component of his/her measuring instrument.

1.2.3 Draws the circuit diagram of his/her measuring instrument, using conventional symbols.

1.2.4 Determines the physical characteristics of the component parts of the measuring instrument.

1.2.5 Indicates on a circuit diagram the characteristics of the components of the measuring instrument.

1.2.6 Has the circuit diagram approved.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

1.3 Construct an instrument to measure at least one variable associated with electric circuits, based on a circuit diagram.

PREREQUISITES:

1.2

RELATED CONTENT:

- SKILL: Organizing data. (G-2)
- KNOWLEDGE: Procedures for constructing a measuring instrument. (A-7)
- ATTITUDE: Creative approach. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Individual work, laboratory work, meeting between the teacher and each student.
B. DURATION: (100/100) minutes in class + free time + work at home.
C. EVALUATION: Working order of the student's measuring instrument.
D. MATERIALS: Depending on the instrument to be constructed.
E. SAFETY MEASURES: Proper use of tools.

SUGGESTED REFERENCES:

LEARNING ACTIVITIES

THE STUDENT:

1.3.0 Recalls procedures for assembling electric circuits (I.T.T. 314).

1.3.1 Lists the materials needed to make the measuring instrument, based on the circuit diagram.

1.3.2 Constructs the measuring instrument in accordance with the diagram drawn in 1.2.

1.3.3 Verifies that the measuring instrument is in working order.

1.3.4 Suggests ways of improving the measuring instrument, if necessary.

1.3.5 Modifies the circuit diagram of his/her measuring instrument in the light of these improvements.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

1.4 Graduate the measuring instrument he/she has constructed, using an arbitrary unit (a unit he/she has determined).

PREREQUISITES:

1.3

RELATED CONTENT:

- **SKILL:** Interpreting data. (D-4)
- **KNOWLEDGE:** Multiples and submultiples of a unit of measure, interpolation, extrapolation. (A-4)
- **ATTITUDE:** Conscientiousness. (H-3)

SUGGESTED TEACHING PLAN:

A. **TEACHING STRATEGY:** Individual work, laboratory work.
B. **DURATION:** (75/75) minutes.
C. **EVALUATION:** Graduation of the student's measuring instrument.
D. **MATERIALS:** Circuit elements needed to produce the physical quantity to be measured.
E. **SAFETY MEASURES:** Precautions in handling lab materials and equipment.

SUGGESTED REFERENCES:

LEARNING ACTIVITIES

THE STUDENT:

1.4.1 Selects the unit of measure for the variable to be measured.

1.4.2 Sets up an arrangement capable of producing the physical quantity that corresponds to the selected unit.

1.4.3 Produces multiples and submultiples of the selected unit.

1.4.4 Graduates the measuring instrument.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

* 1.5 Evaluate the features of the measuring instrument he/she has constructed.

PREREQUISITES:

1.4

RELATED CONTENT:

- SKILL: Measuring. (B-5)
- KNOWLEDGE: Different aspects of scientific measurement, features of a measuring instrument. (A-1)
- ATTITUDE: Critical attitude. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Laboratory work, brainstorming.
B. DURATION: 60 minutes.
C. EVALUATION: Student's method of evaluating the features of a measuring instrument.
D. MATERIALS: Circuit elements needed to produce the physical quantity to be measured.
E. SAFETY MEASURES: Precautions in handling lab materials and equipment.

SUGGESTED REFERENCES:

LEARNING ACTIVITIES

THE STUDENT:

1.5.0 Recalls the concept of scientific measurement (1.1).

1.5.1 Assesses the reliability of his/her measuring instrument by conducting experiments.

1.5.2 Assesses the sensitivity of his/her measuring instrument by conducting experiments.

1.5.3 Compares the precision of his/her measuring instrument with that of other measuring instruments.

1.5.4 Identifies other features of a measuring instrument.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

* 1.6 Make the necessary modifications to improve the features of the measuring instrument he/she has constructed.

PREREQUISITES:

1.5

RELATED CONTENT:

- SKILL: Recognizing a problem. (C-1)
- KNOWLEDGE: Features of a measuring instrument. (A-1)
- ATTITUDE: Creative approach. (D-2)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Brainstorming, laboratory work, individual work.
B. DURATION: 50 minutes in class + work at home.
C. EVALUATION: Effectiveness of modifications to the measuring instrument.
D. MATERIALS: Materials, tools, circuit elements needed to produce the physical quantity to be measured.
E. SAFETY MEASURES: Proper use of tools, precautions in handling lab materials and equipment.

SUGGESTED REFERENCES:

LEARNING ACTIVITIES

THE STUDENT:

1.6.1 Suggests ways of improving his/her measuring instrument.

1.6.2 Incorporates the modifications suggested in 1.6.1.

1.6.3 Verifies the effectiveness of those modifications.

1.6.4 Identifies other modifications that would have to be made to enable the instrument to measure other variables associated with electric circuits.

1.6.5 Corrects the circuit diagram of the measuring instrument he/she has constructed.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and intermediate)

THE STUDENT WILL BE ABLE TO:

** 1.7 Use the measuring instrument he/she has constructed to verify a law or rule discovered in the study of electrical principles.

PREREQUISITES:

1.4

RELATED CONTENT:

-	SKILL:	Measuring. (B-3)
-	KNOWLEDGE:	Equivalences between units of measure. (A-4)
-	ATTITUDE:	Willingness to interpret information. (H-3)

SUGGESTED TEACHING PLAN:

A.	TEACHING STRATEGY:	
	Laboratory work,	Individual work.
B.	DURATION:	(50/200) minutes in class + work at home.
C.	EVALUATION:	Student's measurements.
D.	MATERIALS:	Circuit elements needed to produce the physical quantity to be measured.
E.	SAFETY MEASURES:	Precautions in handling lab materials and equipment.

SUGGESTED REFERENCES:

LEARNING ACTIVITIES

THE STUDENT:

1.7.1 Assembles simple electric circuits consisting of batteries, light bulbs, and switches.

1.7.2 Measures, several times, a variable of the electric circuits assembled in 1.7.1.

1.7.3 Records these measures in a data table.

1.7.4 Establishes mathematical relationships among the variables he/she has measured.

1.7.5 Determines an equivalence relationship between the arbitrary unit of measure and the conventional unit of measure for these variables.

1.7.6 Measures a physical quantity in a conventional unit, using the instrument he/she has constructed.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

** 1.7 Use the measuring instrument he/she has constructed to verify a law or rule discovered in the study of electrical principles.

PREREQUISITES:

1.4

RELATED CONTENT:

- SKILL: Measuring. (B-3)
- KNOWLEDGE: Equivalences between units of measure. (A-4)
- ATTITUDE: Willingness to interpret information. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY: Individual work.
Laboratory work.
B. DURATION: (50/200) minutes in class + work at home.
C. EVALUATION: Student's measurements.
D. MATERIALS: Circuit elements needed to produce the physical quantity to be measured.
E. SAFETY MEASURES: Precautions in handling lab materials and equipment.

SUGGESTED REFERENCES:

LEARNING ACTIVITIES

THE STUDENT:

1.7.1 Assembles simple electric circuits consisting of batteries, light bulbs, and switches.

1.7.2 Measures, several times, a variable of the electric circuits assembled in 1.7.1.

1.7.3 Records these measures in a data table.

1.7.4 Establishes mathematical relationships among the variables he/she has measured.

1.7.5 Determines an equivalence relationship between the arbitrary unit of measure and the conventional unit of measure for these variables.

1.7.6 Measures a physical quantity in a conventional unit, using the instrument he/she has constructed.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and intermediate)

THE STUDENT WILL BE ABLE TO:

* 1.8 Communicate the results of his/her technological research project.

PREREQUISITES:

1.6, 1.7

RELATED CONTENT:

- SKILL: Communicating. (C-4)
- KNOWLEDGE: Methods for presenting experimental results. (A-4)
- ATTITUDE: Self-confidence. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Meetings between the teacher and each student, student's presentation.
B. DURATION: 50 minutes in class + work at home.
C. EVALUATION: Student's research report.
D. MATERIALS: Materials needed to present results.
E. SAFETY MEASURES: Depending on equipment and materials used to present the results.

SUGGESTED REFERENCES:

LEARNING ACTIVITIES

THE STUDENT:

1.8.1 Writes a research report.

1.8.2 Identifies difficulties he/she encountered in doing this project.

1.8.3 Indicates the means used to overcome these difficulties.

1.8.4 Presents the results of the research project.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

2. **Analyze the characteristics of a magnetic field that were examined as part of his/her scientific work.**

   2.1 Distinguish magnetic substances from ferromagnetic and non-magnetic substances.

PREREQUISITES:

Module 1-3.2

RELATED CONTENT:

- SKILL: Organizing data. (B-3)
- KNOWLEDGE: Ferromagnetic substances, remanence, natural magnetic substances, artificial magnetic substances. (A-6)
- ATTITUDE: Intellectual curiosity. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Laboratory work, brainstorming, individual work, class discussion.
B. DURATION: (50/75) minutes.
C. EVALUATION: Student's classification.
D. MATERIALS: Magnets, paper clips, pins, pencils, coins, jewelry, and so on.
E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

Videos: - **Le Magnétisme**, 14 min, Multimédia Audio-visuel Inc., Montréal.
*- **L'univers de l'électricité**, 29 min, TV Ontario.
*- **J'aime les aimants**, 25 min, TV Ontario.

LEARNING ACTIVITIES

THE STUDENT:

2.1.0 Recalls the principles of magnetism (Physical Sciences 214).

Recalls the magnetic property of certain substances (Module 1-3.2).

2.1.1 Identifies magnetic phenomena in his/her environment.

2.1.2 Becomes aware of the distinctions between magnetism, ferromagnetism and non-magnetism.

2.1.3 Suggests ways of distinguishing magnetic substances from ferromagnetic and non-magnetic substances.

2.1.4 Classifies given substances as magnetic, ferromagnetic, and non-magnetic.

2.1.5 Compares his/her classification with those of the other students.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

2.2 Map the magnetic fields of magnetized objects.

PREREQUISITES:

2.1

RELATED CONTENT:

- SKILL: Formulating hypotheses. (C-2)
- KNOWLEDGE: North pole and South pole of a magnet, conventional way of mapping magnetic fields, laws of magnetic attraction and repulsion. (A-8)
- ATTITUDE: Fascination with science. (H-4)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Laboratory work, individual work, presentation.
B. DURATION: (50/75) minutes in class + work at home.
C. EVALUATION: Student's knowledge of laws.
D. MATERIALS: Magnets of various shapes, iron filings, compass, plastic bags, sheet of glass or cardboard.
E. SAFETY MEASURES: Cleanliness, goggles when using filings.

SUGGESTED REFERENCES:

HIRSCH, A. **Physics: A Practical Approach.** Toronto: John Wiley and Sons, 1981, pp. 332-335.
*Videos: - **J'aime les aimants**, 25 min, TV Ontario.

LEARNING ACTIVITIES

THE STUDENT:

2.2.1 Suggests the configuration of the magnetic field around a bar magnet, using a drawing.

2.2.2 Tests the hypothesis formulated in 2.2.1 by conducting an experiment.

2.2.3 Makes a drawing that represents the magnetic field around a bar magnet, based on what he/she observed in 2.2.2.

2.2.4 Identifies the magnetic poles of the magnet, using a compass.

2.2.5 Becomes aware of the conventional way of representing magnetic lines of force.

2.2.6 Sketches what he/she thinks is the magnetic field between two magnetized objects that have been brought together.

2.2.7 Tests the hypothesis formulated in 2.2.6 by conducting an experiment.

2.2.8 Illustrates the observed phenomena, using the conventions for mapping magnetic fields.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and intermediate)

THE STUDENT WILL BE ABLE TO:

2.3 Map the magnetic field around a current-bearing solenoid.

PREREQUISITES:

Module 1-4.5, Module 2-2.2

RELATED CONTENT:

- SKILL: Generalizing. (F-1)
- KNOWLEDGE: Magnetic field, magnetic lines of force for a straight wire and a solenoid. (A-4)
- ATTITUDE: Fascination with science. (H-4)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Brainstorming, laboratory work, individual work, group work.
B. DURATION: (175/200) minutes in class + work at home.
C. EVALUATION: Student's diagrams of the configurations of magnetic fields.
D. MATERIALS: Conducting wire, solenoids, iron filings, sources of direct current.
E. SAFETY MEASURES: Precautions in handling lab materials and equipment.

SUGGESTED REFERENCES:

HIRSCH, A. **Physics: A Practical Approach.** Toronto: John Wiley and Sons, 1981, pp. 336-340.

LEARNING ACTIVITIES

THE STUDENT:

2.3.0 Recalls the procedure for making a solenoid (I.T.T. 314).

Recalls the concept of the direction of an electric current (I.T.T. 314, Module 1-4.5).

2.3.1 Suggests the configurations of magnetic fields around a straight current-bearing wire, using diagrams

2.3.2 Develops an experimental procedure to test the hypotheses formulated in 2.3.1.

2.3.3 Uses a mnemonic device to find the direction of the lines of force around a straight wire from the direction of the electric current flowing through it.

2.3.4 Suggests the configurations of magnetic fields around current-bearing solenoids, using diagrams.

2.3.5 Develops an experimental procedure for identifying the magnetic poles of current-bearing solenoids.

2.3.6 Corrects his/her hypotheses, if necessary.

2.3.7 Proposes a rule to describe the relationship between the direction of the electric current and the direction of the lines of force around a current-bearing solenoid.

2.3.8 Writes a report on the experiments he/she has conducted.

2.3.9 Lists technical objects in his/her environment that contain solenoids.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and intermediate)

THE STUDENT WILL BE ABLE TO:

2.4 Demonstrate the effect of a core on the behaviour of an electromagnet, after conducting an experiment.

PREREQUISITES:

2.3

RELATED CONTENT:

- SKILL: Interpreting data. (D-5)
- KNOWLEDGE: Electromagnets, role of the core, effect of the nature of the core. (A-1)
- ATTITUDE: Intellectual curiosity. (H-4)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Brainstorming, laboratory work, individual work.
B. DURATION: (125/150) minutes in class + work at home.
C. EVALUATION: Student's report on lab experiment.
D. **MATERIALS:** Conducting wire, core, solenoids, sources of direct current.
E. SAFETY MEASURES: Precautions in handling lab materials and equipment.

SUGGESTED REFERENCES:

SPENCER, P.; McNEILL, K. and MACLACHLAN, J. **Matter and Energy.** Richmond Hill, Ont.: Irwin Publishing Inc., 1978, p. 298.

LEARNING ACTIVITIES

THE STUDENT:

2.4.1 Formulates hypotheses to explain how a soft iron core changes the magnetic field around a solenoid.

2.4.2 Justifies his/her hypotheses.

2.4.3 Tests his/her hypotheses by conducting an experiment.

2.4.4 Verifies the effect of different types of cores on the magnetic field around an electromagnet by means of an experiment.

2.4.5 Writes a report on the experiments he/she has conducted.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and intermediate)

THE STUDENT WILL BE ABLE TO:

** 2.5 Explain the properties of magnetized matter, using the simplified atomic model currently in use.

PREREQUISITES:

Module 1-4, Module 2-2.1, 2.3

RELATED CONTENT:

- SKILL: Constructing a model. (E-1)
- KNOWLEDGE: Theory of magnetism, magnetization by induction, magnetization by particle alignment, mechanical effects on magnetism, Curie temperature. (A-9)
- ATTITUDE: Willingness to compare ideas. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Laboratory work, group work, demonstration, class discussion.
B. DURATION: (50/75) minutes.
C. EVALUATION: Student's hypotheses.
D. MATERIALS: Iron filings, test tubes, magnetic substances, bunsen burner, hammer, compass, magnets, solenoids, power supply.
E. SAFETY MEASURES: Precautions related to heating.

SUGGESTED REFERENCES:

SPENCER, P.; McNEILL, K. and MACLACHLAN, J. **Matter and Energy.** Richmond Hill, Ont.: Irwin Publishing Inc., 1978, pp. 281-284.

LEARNING ACTIVITIES

THE STUDENT:

2.5.0 Recalls the simplified atomic model currently in use (Module 1-4).

Recalls the magnetic effect produced by the electric current flowing through a solenoid (Module 2-2.3).

2.5.1 Suggests methods of magnetizing or demagnetizing substances.

2.5.2 Tests the proposed methods by means of an experiment.

2.5.3 Magnetizes and demagnetizes substances by following suggested experimental procedures.

2.5.4 Formulates hypotheses to explain the concepts of magnetization and demagnetization, based on the simplified atomic model.

2.5.5 Compares his/her hypotheses with those of the other students.

2.5.6 Compares his/her hypotheses with the phenomena observed during a demonstration.

2.5.7 Re-assesses the atomic model in the light of what he/she has learned from observing magnetic and electromagnetic phenomena.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

2.6 Identifies the factors that affect the magnetic field of an electromagnet, after conducting experiments.

PREREQUISITES:

2.4

RELATED CONTENT:

- SKILL:	Developing an experimental procedure. (C-3)
- KNOWLEDGE:	Factors that affect the magnetic field of an electromagnet: number of turns, current intensity, type of core. (A-1)
- ATTITUDE:	Creative approach. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Brainstorming, individual work, laboratory work, class discussion.

B. DURATION:	(75/100) minutes.
C. EVALUATION:	Student's experimental procedure.
D. MATERIALS:	Variable source of direct current, various solenoids, various electromagnets, galvanometer.
E. SAFETY MEASURES:	Precautions in handling lab materials and equipment.

SUGGESTED REFERENCES:

LEARNING ACTIVITIES

THE STUDENT:

2.6.1 Suggests factors that can affect the magnetic field of an electromagnet.

2.6.2 Develops an experimental procedure to test the hypotheses formulated in 2.6.1.

2.6.3 Compares his/her results with those of the other students.

2.6.4 Writes a report on the experiments he/she has conducted.

2.6.5 Becomes aware of other factors that may affect the magnetic field of an electromagnet.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

** 2.7 Determine the mathematical relationship among the parameters that affect the magnetic force (magnetomotive force) of an electromagnet, after conducting an experiment.

PREREQUISITES:

2.6

RELATED CONTENT:

- SKILL: Interpreting data. (D-2)
- KNOWLEDGE: Mathematical relationships among the parameters that affect magnetic force (Mf, N, I). (A-9)
- ATTITUDE: Conscientiousness. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Group work, laboratory work, class discussion.
B. DURATION: (50/75) minutes.
C. EVALUATION: Student's interpretation of the graphs.
D. MATERIALS: Variable source of direct current, various solenoids, mild steel core, spring balance, ruler, ring stand.
E. SAFETY MEASURES: Precautions in handling lab materials and equipment.

SUGGESTED REFERENCES:

Video: **Electricity**, 15 min, Hydro-Québec, 1972.

LEARNING ACTIVITIES

THE STUDENT:

2.7.1 Draws the following two graphs after conducting an experiment in accordance with the suggested procedure:

a) a graph showing the relationship between the magnetic force (magnetomotive force) of an electromagnet and the number of turns.

b) a graph showing the relationship between the magnetic force (magnetomotive force) of an electromagnet and current intensity.

2.7.2 Proposes a mathematical relationship among the following three elements: the number of turns, current intensity, and magnetic force (magnetomotive force).

2.7.3 Compares his/her mathematical relationship with those of the other students.

2.7.4 Discusses the unit used to measure the magnetic force (magnetomotive force) of an electromagnet.

2.7.5 Writes a report on the experiment he/she has conducted.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and intermediate)

THE STUDENT WILL BE ABLE TO:

2.8 Justify applying the principles of magnetism and electromagnetism in the manufacture of consumer goods.

PREREQUISITES:

2.1

RELATED CONTENT:

- SKILL: Generalizing. (F-3)
- KNOWLEDGE: Application of the principles of magnetism and electromagnetism to produce consumer goods, technological applications. (A-10)
- ATTITUDE: Critical attitude. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Brainstorming, group work, individual work, class discussion.
B. DURATION: (30/50) minutes in class + work at home.
C. EVALUATION: Student's argumentation.
D. MATERIALS: Relevant reference materials.
E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

*Video: **ABOUT SCIENCE SERIES**, TV Ontario, Tape 6, 25 min.

LEARNING ACTIVITIES

THE STUDENT:

2.8.1 Lists consumer goods produced through the application of magnetic and electromagnetic principles.

2.8.2 Describes the role of magnetism and electromagnetism in these consumer goods.

2.8.3 Describes the economic and environmental impact of the application of magnetic and electromagnetic principles in the manufacture of consumer goods.

2.8.4 Discusses the impact of magnetism and electromagnetism on human health.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and intermediate)

THE STUDENT WILL BE ABLE TO:

** 2.9 Trace the history of the discovery and application of the principles of magnetism and electromagnetism by consulting reference materials.

PREREQUISITES:

RELATED CONTENT:

- SKILL: Communicating. (F-4)
- KNOWLEDGE: History of the discovery and application of the principles of magnetism and electromagnetism. (A-1)
- ATTITUDE: "Constructivist" view of science. (I-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
individual work, brainstorming, group work, class discussion.
B. DURATION: (50/75) minutes in class + work at home.
C. EVALUATION: Student's paper.
D. MATERIALS: Reference materials.
E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

MORICE, Gérard. "Électricité sans fil: Le rêve devient réalité", **Science et vie**, N° 832, (janvier 1987), pp. 114 et 115.
16 mm Film: **Learning About Magnetism**, 14 min, Britannica Learning Materials.

LEARNING ACTIVITIES

THE STUDENT:

2.9.0 Recalls the applications of magnetic principles throughout history (History 214, I.T.T. 314).

2.9.1 Identifies scientists who studied magnetism and electromagnetism.

2.9.2 Shows how magnetism and electromagnetism played major roles in changing human activities in different historical periods.

2.9.3 Identifies the latest areas of research into magnetism and electromagnetism.

2.9.4 Formulates hypotheses regarding the future applications of magnetic and electromagnetic principles.

2.9.5 Writes a short paper on the application of magnetic principles.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and intermediate)

THE STUDENT WILL BE ABLE TO:

3. **Analyze the variables associated with various combinations of circuit elements that he/she used while doing scientific work.**

   3.1 Justify using certain substances to assemble electric circuits, based on the properties of those substances.

PREREQUISITES:

Module 1-5.4

RELATED CONTENT:

- SKILL: Organizing data. (D-1)
- KNOWLEDGE: Conductivity, conductors, insulators. (A-6)
- ATTITUDE: Intellectual curiosity. (A-1)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Individual work, laboratory work, class discussion.

B. DURATION: (25/50) minutes in class + work at home.

C. EVALUATION: Student's justification.

D. MATERIALS: Reference materials, power supply, light bulb, conducting wire, substances with different conductances.

E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

Videos:
- **Les conducteurs électriques**, 15 min, Multimédia, Audiovisuel Inc., Montreal.
- **CONCEPTS IN SCIENCE SERIES**, TV Ontario, Tape 7 - **Electricity**, one 10-minute program: 1. **Conductors and insulators.**

LEARNING ACTIVITIES

THE STUDENT:

3.1.0 Recalls how to assemble an electric circuit (1.7.7, 3.4).

Recalls the definition of a characteristic property of matter (Module 1-2).

3.1.1 Identifies substances used to assemble standard electric circuits.

3.1.2 Suggests a system for classifying these substances on the basis of their conductivity.

3.1.3 Modifies this classification after conducting experiments.

3.1.4 Lists circuit elements used because of the conductivity of their components.

3.1.5 Becomes aware of various types of conductors and insulators by consulting reference materials.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and intermediate)

THE STUDENT WILL BE ABLE TO:

3.2 Determine how various factors affect the conductivity of given materials, by conducting an experiment.

PREREQUISITES:

3.1

RELATED CONTENT:

- SKILL:	Developing an experimental procedure. (C-4)
- KNOWLEDGE:	Effects of length, cross section, type of material, and temperature on electrical conductivity; superconductivity. (A-5)
- ATTITUDE:	Objectivity. (m-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Laboratory work, individual work, demonstration, class discussion.

B. DURATION: (125/150) minutes.

C. EVALUATION: Student's observations.

D. MATERIALS: Power supply, conductors of different lengths, cross sections, and materials, source of heat, light bulb, conducting wire, scale of luminosity (from very bright to no visible light), superconductivity kit.

E. SAFETY MEASURES: Heat, cold.

SUGGESTED REFERENCES:

BLACKWOOD, O.; HERRON, W.; and KELLY, W. **Electrical Circuits.** Toronto: Ginn and Company, 1967, pp. 432-435.

HIRSCH, A. **Physics: A Practical Approach**, section on electric resistance. Toronto: John Wiley and Sons, 1981.

PAUL, D.; PIERCE, D. and STIEF, W. **Electricity.** Toronto: Holt, Rinehart and Winston of Canada Limited, 1976, pp. 20-22.

LEARNING ACTIVITIES

THE STUDENT:

3.2.0 Recalls the characteristic properties of given substances (Module 1-2.2).

3.2.1 Suggests factors that can affect the conductivity of various materials.

3.2.2 Develops an experimental procedure to determine how these factors affect the conductance of these materials.

3.2.3 Conducts a laboratory experiment.

3.2.4 Illustrates the relationship between the conductivity of materials and a particular factor, using diagrams.

3.2.5 Illustrates the influence of these factors, by giving examples of technological applications.

3.2.6 Formulates hypotheses regarding the conductivity of materials at extreme temperatures.

3.2.7 Tests these hypotheses by conducting an experiment.

3.2.8 Becomes aware of the conductivity of materials at low temperatures.

3.2.9 Discusses how scientific and technological discoveries have contributed to our knowledge of the characteristic properties of given substances.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

3.3 Measure current intensities in a circuit element.

PREREQUISITES:

2.6

RELATED CONTENT:

- SKILL: Measuring. (G-1)
- KNOWLEDGE: Measure of current intensity, schematic diagram of an ammeter in an electric circuit, unit of current intensity. (A-4)
- ATTITUDE: Sense of responsibility (concern for the environment). (D-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
individual work, demonstration, laboratory work, presentation, simulation, group work.
B. DURATION: (50/75) minutes.
C. EVALUATION: Student's ability to use an ammeter.
D. MATERIALS: Power supply, switch, circuit elements, conducting wire, ammeter.
E. SAFETY MEASURES: Precautions in handling the ammeter.

SUGGESTED REFERENCES:

16 mm Film: **What is Electric Current?**, 10 min, Britannica Learning Materials.

LEARNING ACTIVITIES

THE STUDENT:

3.3.0 Recalls schematic diagrams of simple electric circuits (I.T.T. 314).

Recalls how to assemble simple electric circuits (I.T.T. 314).

3.3.1 Draws schematic diagrams of simple electric circuits consisting of a power supply, a switch, and a circuit element, using conventional symbols.

3.3.2 Assembles the circuits illustrated in those diagrams.

3.3.3 Formulates his/her conception of an electric current.

3.3.4 Becomes aware of the conventional unit of current intensity.

3.3.5 Becomes familiar with the use of an ammeter.

3.3.6 Draws properly connected ammeters in his/her circuit diagrams, using conventional symbols.

3.3.7 Measures current intensities in his/her circuits.

3.3.8 Indicates these current intensities in the schematic diagrams.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

3.4 Measure potential differences in simple circuits.

PREREQUISITES:

2.6

RELATED CONTENT:

- SKILL:	Measuring. (G-1)
- KNOWLEDGE:	Measure of potential difference, schematic diagram of a voltmeter in an electric circuit, unit of measure for potential difference. (A-4)
- ATTITUDE:	Conscientiousness. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Demonstration, laboratory work, presentation, simulation, individual work.

B. DURATION:	(75/100) minutes.
C. EVALUATION:	Student's ability to use a voltmeter.
D. MATERIALS:	Power supply, switch, circuit elements, conducting wire, voltmeter.
E. SAFETY MEASURES:	Precautions in handling lab materials and equipment.

SUGGESTED REFERENCES:

Videos:
- **Le circuit électrique**, 9 min, Multi-média, Audiovisuel Inc., Montréal.
- **Les montages électriques**, 8 min, Multi-média, Audiovisuel Inc., Montréal.

LEARNING ACTIVITIES

THE STUDENT:

3.4.0 Recalls the concept of potential difference (I.T.T. 314).

3.4.1 Draws schematic diagrams of simple electric circuits consisting of a power supply, a switch, and a circuit element, using conventional symbols.

3.4.2 Assembles the circuits illustrated in those diagrams.

3.4.3 Becomes aware of the conventional unit of measure for potential difference.

3.4.4 Becomes aware of the use of a voltmeter in an electric circuit.

3.4.5 Draws properly connected voltmeters in his/her circuit diagrams, using conventional symbols.

3.4.6 Measures potential difference across the element in each of his/her circuits.

3.4.7 Indicates these potential differences in the schematic diagrams.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and intermediate)

THE STUDENT WILL BE ABLE TO:

3.5 Determine the conductance of a circuit element, using a graph.

PREREQUISITES:

3.3, 3.4

RELATED CONTENT:

- SKILL:	Interpreting data. (B-2)
- KNOWLEDGE:	Physical significance of the rate of change on a graph, constant of proportionality, conductance, Ohm's law, unit of measure for conductance. (A-8)
- ATTITUDE:	Intellectual curiosity. (D-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Laboratory work, group work, individual work, presentation.

B. DURATION:	(125/150) minutes.
C. EVALUATION:	Student's interpretation of graphs.
D. MATERIALS:	Power supply, circuit elements, resistor, ammeter, voltmeter, conducting wire, millimetric graph paper.
E. SAFETY MEASURES:	Precautions in handling lab materials and equipment.

SUGGESTED REFERENCES:

*Video: **CONCEPTS IN SCIENCE SERIES**, TV Ontario,
Tape 7 - **Electricity**, one 10-minute
program: 1. **Conductors and Insulators.**

LEARNING ACTIVITIES

THE STUDENT:

3.5.0 Recalls the characteristic properties of matter. (Module 1-2.2).

3.5.1 Develops an experimental procedure to measure the current flowing through resistors when different voltages are applied to the circuit.

3.5.2 Draws a graph showing that current intensity (I) is a function of potential difference (V) (I = f (V)).

3.5.3 Establishes a mathematical relationship between current intensity and voltage.

3.5.4 Associates the constant of proportionality with the value of the conductance of the resistors.

3.5.5 Associates conductance with a property of matter.

3.5.6 Becomes aware of the unit used to measure conductance.

3.5.7 Becomes aware of the definition of conductance formulated by Georg Simon Ohm in the nineteenth century.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and intermediate)

THE STUDENT WILL BE ABLE TO:

3.6 Distinguish between the conductance and the resistance of a circuit element.

PREREQUISITES:

3.5

RELATED CONTENT:

- SKILL: Generalizing. (E-6)
- KNOWLEDGE: Electrical resistance, unit of electrical resistance. (A-8)
- ATTITUDE: Willingness to synthesize and apply knowledge. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Brainstorming, presentation, individual work, group work.
B. DURATION: (50/75) minutes.
C. EVALUATION: Student's ability to distinguish between electrical conductance and resistance.
D. MATERIALS: Various resistors, reference materials.
E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

Videos: *- **ABOUT SCIENCE SERIES**, TV Ontario, three 5-minute programs: 17. **An Electric Circuit**; 18. **A Series Circuit**; 19. **A Parallel Circuit**.
- **Electrotechnologies and Industry: Resistance Heating**, 15 min, Hydro Québec, 1989.
*- **ELECTRICITY SERIES**, TV Ontario, One 10 - minute program: **Resistance**.

LEARNING ACTIVITIES

THE STUDENT:

3.6.1 Describes his/her conception of electrical resistance.

3.6.2 Becomes aware of what the resistance of a circuit element represents.

3.6.3 Becomes aware of the unit of measure for electrical resistance.

3.6.4 Establishes a mathematical relationship between the conductance (i.e. 3.5) and the resistance of a circuit element.

3.6.5 Becomes aware of a code used to represent the value of a resistor by consulting reference materials.

3.6.6 Determines the electrical resistance of given resistors, using a code.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and intermediate)

THE STUDENT WILL BE ABLE TO:

3.7 Determine the equivalent resistance of series and parallel circuits kept at constant temperature.

PREREQUISITES:

3.6

RELATED CONTENT:

- SKILL: Interpreting data. (D-2)
- KNOWLEDGE: Equivalent resistances of series and parallel circuits. (A-7)
- ATTITUDE: Willingness to clarify problems. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Group work, laboratory work, class discussion, individual work.

B. DURATION: (175/200) minutes in class + work at home.

C. EVALUATION: Student's research paper.

D. MATERIALS: Power supply, conducting wire, switch, resistors, ammeter, voltmeter, thermometer.

E. SAFETY MEASURES: Precautions in handling lab materials and equipment.

SUGGESTED REFERENCES:

*Video: **ABOUT SCIENCE SERIES**, TV Ontario, one 5-minute program: **18. A Series Circuit.**

LEARNING ACTIVITIES

THE STUDENT:

3.7.1 Develops an experimental procedure to determine the equivalent resistance in series and parallel circuits.

3.7.2 Draws graphs which show that the potential difference (V) across the terminals in series and parallel circuits is a function of the current intensity (I) in those circuits ($V = f(I)$).

3.7.3 Determines the equivalent resistance for series and parallel circuits by referring to these graphs.

3.7.4 Measures the equivalent resistance of the series and parallel circuits used in 3.7.1, by means of an ohmmeter.

3.7.5 Compares these experimental results with the equivalent resistances obtained in 3.7.3.

3.7.6 Formulates explanations for the possible differences between the measures obtained in 3.7.4 and the values determined in 3.7.3.

3.7.7 Suggests mathematical relationships pertaining to the equivalent resistance of series and parallel circuits.

3.7.8 Compares his/her hypotheses with those of the other students.

3.7.9 Calculates the equivalent resistance of these circuits using the mathematical relationships suggested in 3.7.7.

3.7.10 Compares the equivalent resistances obtained in 3.7.3 with the results obtained in 3.7.4 and 3.7.9.

3.7.11 Finds examples of series and parallel circuits in his/her environment.

3.7.12 Writes a research report.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

* 3.8 Determine the equivalent resistance of a series-parallel circuit kept at constant temperature.

PREREQUISITES:

3.7

RELATED CONTENT:

- SKILL:	Interpreting data. (D-3)
- KNOWLEDGE:	Equivalent resistances in series-parallel circuits. (A-7)
- ATTITUDE:	Willingness to interpret information. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Group work, laboratory work, individual work, simulation, class discussion.

B. DURATION: 100 minutes in class + work at home.

C. EVALUATION: Student's experimental procedure.

D. MATERIALS: Power supply, conducting wire, switch, resistor, ammeter, voltmeter, ohmmeter.

E. SAFETY MEASURES: Precautions in handling lab materials and equipment.

SUGGESTED REFERENCES:

*Video: **ABOUT SCIENCE SERIES**, TV Ontario, Two 5-minute programs: **18. A Series Circuit; 19. A Parallel Circuit.**

LEARNING ACTIVITIES

THE STUDENT:

3.8.1 Develops a procedure for measuring the equivalent resistance of a series-parallel circuit kept at constant temperature.

3.8.2 Proposes mathematical relationships for calculating the equivalent resistance of series-parallel circuits.

3.8.3 Calculates the equivalent resistance of the circuit used in 3.8.1.

3.8.4 Compares the equivalent resistance calculated in 3.8.3 with results obtained in 3.8.1.

3.8.5 Discusses possible differences between the calculated value and the measured value of equivalent resistance.

3.8.6 Writes a research report.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

3.9 Evaluate the significance of the error in the measurement of electrical resistance.

PREREQUISITES:

3.7, 3.8

RELATED CONTENT:

- SKILL: Measuring. (B-5)
- KNOWLEDGE: Features of a measuring instrument, concept of error. (A-6)
- ATTITUDE: Conscientiousness. (A-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Presentation, group work, laboratory work, class discussion.
B. DURATION: (125/150) minutes.
C. EVALUATION: Student's ability to identify causes of error in measurement.
D. MATERIALS: Power supply, conducting wire, switch, resistors, ammeter, voltmeter, ohmmeter.
E. SAFETY MEASURES: Precautions in handling lab materials and equipment.

SUGGESTED REFERENCES:

LEARNING ACTIVITIES

THE STUDENT:

3.9.0 Recalls the possible differences between the measured values of the same physical quantity, using the techniques covered in 3.7.

3.9.1 Discusses the concept of absolute and relative error.

3.9.2 Determines the value of the absolute error for the resistances measured in 3.7 and 3.8.

3.9.3 Calculates the relative error for these measures.

3.9.4 Formulates hypotheses to explain these errors.

3.9.5 Assesses the precision of the measuring instruments he/she has used, by conducting experiments.

3.9.6 Assesses the sensitivity of the measuring instruments he/she has used, by conducting experiments.

3.9.7 Assesses the sensitivity of the measuring instruments he/she has used, by conducting experiments.

3.9.8 Identifies the causes of error, if applicable.

3.9.9 Suggests ways of improving measuring techniques in order to minimize errors.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and intermediate)

THE STUDENT WILL BE ABLE TO:

** 3.10 Explain the effect of incorporating a measuring instrument into an electric circuit.

PREREQUISITES:

3.3, 3.4, 3.7, 3.9

RELATED CONTENT:

- SKILL: Measuring. (B-9)
- KNOWLEDGE: Errors caused by the instrument. (A-7)
- ATTITUDE: Conscientiousness. (M-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Group work, laboratory work, individual work, simulation, class discussion.

B. DURATION: (90/75) minutes in class + work at home.

C. EVALUATION: Student's paper.

D. MATERIALS: Power supply, switch, circuit elements, conducting wire, measuring instruments (voltmeter, ammeter).

E. SAFETY MEASURES: Precautions in handling lab materials and equipment.

SUGGESTED REFERENCES:

LEARNING ACTIVITIES

THE STUDENT:

3.10.0 Recalls techniques for measuring current intensity, potential difference, and electrical resistance.

3.10.1 Develops a procedure to test the following hypothesis: a measuring instrument distorts the value of the variable to be measured.

3.10.2 Estimates measurement errors caused by the measuring instrument.

3.10.3 Suggests ways of improving the measuring instrument and the measuring technique.

3.10.4 Tests his/her hypotheses by means of an experiment.

3.10.5 Writes a paper on how measurements affect results in scientific research.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

3.11 Analyze the distribution of current in various combinations of circuit elements.

PREREQUISITES:

3.3

RELATED CONTENT:

- SKILL: Generalizing. (D-8)
- KNOWLEDGE: Law regarding electric currents. (A-8)
- ATTITUDE: Willingness to compare ideas. (M-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Laboratory work, simulation, individual work, group work, class discussion.

B. DURATION: (125/150) minutes in class + work at home.

C. EVALUATION: Student's understanding of law regarding electric currents.

D. MATERIALS: Power supply, switch, circuit elements, conducting wire, ammeter.

E. SAFETY MEASURES: Precautions in handling lab materials and equipment.

SUGGESTED REFERENCES:

*Videos:
- **CONCEPTS IN SCIENCE SERIES.** TV Ontario, Tape 7 - Electricity, one 10-minute program: **4. Current Electricity.**
- **ELECTRICITY SERIES.** TV Ontario, a series of six 10-minute programs: **1. Conductors and Insulators; 2. Charging and Discharging; 3. Charging by Induction; 4. Current Electricity; 5. Potential Difference; 6. Resistance.**

LEARNING ACTIVITIES

THE STUDENT:

3.11.1 Assembles an electric circuit on the basis of a schematic diagram.

3.11.2 Formulates hypotheses regarding the distribution of current in the circuit.

3.11.3 Develops a procedure to test these hypotheses.

3.11.4 Formulates a law regarding the distribution of current in the circuit, based on his/her measurements.

3.11.5 Compares his/her law with those of the other students.

3.11.6 Compares his/her law with the one formulated by German physicist Gustav Robert Kirchhoff in the nineteenth century.

3.11.7 Writes a report on the experiment he/she has conducted.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and intermediate)

THE STUDENT WILL BE ABLE TO:

3.12 Explain the distribution of electric potential in various combinations of circuit elements.

PREREQUISITES:

3.4

RELATED CONTENT:

- SKILL: Generalizing. (D-6)
- KNOWLEDGE: Law regarding voltage. (A-6)
- ATTITUDE: Willingness to compare ideas. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Group work, laboratory work, individual work, simulation, class discussion.

B. DURATION: (75/100) minutes in class + work at home.

C. EVALUATION: Student's understanding of law regarding voltage.

D. MATERIALS: Power supply, switch, circuit elements, conducting wire, voltmeter.

E. SAFETY MEASURES: Precautions in handling lab materials and equipment.

SUGGESTED REFERENCES:

GIANCOLI, D. **The Ideas of Physics.** Don Mills, Ont.: Academic Press Canada, pp. 350-352.

LEARNING ACTIVITIES

THE STUDENT:

3.12.1 Formulates a hypothesis regarding the distribution of voltage in series and parallel circuits.

3.12.2 Develops a procedure to test this hypothesis.

3.12.3 Formulates a law regarding the distribution of electric potential in series and parallel circuits, based on his/her measurements.

3.12.4 Compares his/her law with those of the other students.

3.12.5 Compares his/her law with the one formulated by German physicist Gustav Robert Kirchhoff in the nineteenth century.

3.12.6 Writes a report on the experiment he/she has conducted.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and intermediate)

THE STUDENT WILL BE ABLE TO:

** 3.13 Explain the concept of electrical potential difference in circuits, using an analogical model.

PREREQUISITES:

3.12

RELATED CONTENT:

- SKILL:	Constructing a model. (E-1)
- KNOWLEDGE:	Analogical model of potential and electrical potential difference. (A-9)
- ATTITUDE:	Critical attitude. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Brainstorming, individual work, simulation, presentation, class discussion.
B. DURATION: (50/75) minutes in class + work at home.
C. EVALUATION: Student's ability to use models.
D. MATERIALS: Reference materials.
E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

16 mm Film: **Electrical Potential Energy**, Part 1, 27 min, Ward's Natural Science Establishment.

LEARNING ACTIVITIES

THE STUDENT:

3.13.0 Recalls concepts related to energy (Ecology 114, Physical Sciences 214, Human Biology 314).

3.13.1 Formulates his/her conception of potential and potential difference.

3.13.2 Becomes aware of an analogical model of electric potential and electrical potential difference.

3.13.3 Uses a model to represent the distribution of electric potential in various combinations of circuit elements.

3.13.4 Discusses the appropriateness of using a model to understand physical phenomena.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and intermediate)

THE STUDENT WILL BE ABLE TO:

3.14 Explain the behaviour of unknown circuits, using the rules of electric circuits.

PREREQUISITES:

3.3, 3.4, 3.11, 3.12

RELATED CONTENT:

-	SKILL:	Interpreting data. (D-3)
-	KNOWLEDGE:	Operation of electric circuits. (A-10)
-	ATTITUDE:	Creative approach. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Laboratory work, group work, individual work, simulation.

B. DURATION: (175/200) minutes in class + work at home.

C. EVALUATION: Student's solutions.

D. MATERIALS: Unknown circuits based on Ohm's law and the laws regarding electric currents and voltage, power supply, switches, conducting wire, circuit elements, tools, materials, measuring instruments.

E. SAFETY MEASURES: Respect for public and private property.

SUGGESTED REFERENCES:

HIRSCH, A. **Physics: A Practical Approach.** Toronto: John Wiley and Sons, 1981, pp. 307-312.

LEARNING ACTIVITIES

THE STUDENT:

3.14.1 Observes the "behaviour" of unknown circuits presented by the teacher.

3.14.2 Measures the physical quantities related to the solution of unknown circuits, if necessary.

3.14.3 Suggests schematic diagrams that represent unknown circuits.

3.14.4 Tests his/her hypotheses by assembling the circuits shown in his/her schematic diagrams.

3.14.5 Modifies the diagrams, if necessary.

3.14.6 Assembles an unknown circuit that other students must solve.

3.14.7 Solves unknown circuits presented by other students.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

3.15 Solve numerical problems that deal with the mathematical relationships between the different physical quantities associated with series and parallel circuits.

PREREQUISITES:

3.5, 3.6, 3.7, 3.11, 3.12

RELATED CONTENT:

- SKILL: Interpreting data. (D-1)
- KNOWLEDGE: Procedure to calculate the equivalent resistance of series circuits and parallel circuits, numerical application of Ohm's law and of the laws regarding voltage and electric currents. (A-7)
- ATTITUDE: Conscientiousness. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Group work, individual work.
B. DURATION: (125/150) minutes in class + work at home.
C. EVALUATION: Student's methods of circulation.
D. MATERIALS: Calculator (optional).
E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

HIRSCH, A. **Physics: A Practical Approach.** Toronto: John Wiley and Sons, 1981, pp. 313-314.

LEARNING ACTIVITIES

THE STUDENT:

3.15.1 Identifies the information needed to solve a problem.

3.15.2 Identifies the appropriate unit of measurement for the physical quantities used in each problem.

3.15.3 Uses mathematical operators correctly when solving a problem.

3.15.4 Verifies that the answer is plausible, using unit analysis.

3.15.5 Verifies that the answer is plausible by calculating the order of magnitude.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and intermediate)

THE STUDENT WILL BE ABLE TO:

- 3.16 Solve numerical problems that deal with the mathematical relationships between the different physical quantities associated with series-parallel circuits.

PREREQUISITES:

3.8, 3.11, 3.12

RELATED CONTENT:

- SKILL: Interpreting data. (D-1)
- KNOWLEDGE: Procedure to calculate equivalent resistance in series and parallel circuits and in series-parallel circuits, numerical application of Ohm's law and of the laws regarding voltage and electric currents. (A-7)
- ATTITUDE: Conscientiousness. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Group work, individual work.
B. DURATION: 100 minutes in class + work at home.
C. EVALUATION: Student's methods of calculation.
D. MATERIALS: Calculator (optional).
E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

Videos:
- **Le circuit série**, 10 min, Multimédia, Audiovisuel Inc., Montréal.
- **Le circuit parallèle**, 11 min, Multimédia, Audiovisuel Inc., Montréal.
- **Le circuit mixte**, 13 min, Multimédia, Audiovisuel Inc., Montréal.

LEARNING ACTIVITIES

THE STUDENT:

3.16.1 Identifies the information needed to solve a problem.

3.16.2 Identifies the appropriate unit of measurement for the physical quantities used in each problem.

3.16.3 Uses mathematical operators correctly when solving a problem.

3.16.4 Verifies that the answer is plausible, using unit analysis.

3.16.5 Verifies that the answer is plausible by calculating the order of magnitude.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

** 3.17 Solve numerical problems dealing with the mathematical relationships between the different physical quantities associated with the values of resistors.

PREREQUISITES:

3.2, 3.6

RELATED CONTENT:

- SKILL: Interpreting data. (D-1)
- KNOWLEDGE: Procedure to calculate resistivity, electrical resistance as a function of the length, cross section, material, and temperature. (A-7)
- ATTITUDE: Conscientiousness. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Group work, individual work.
B. DURATION: (75/100) minutes in class + work at home.
C. EVALUATION: Student's methods of calculation.
D. MATERIALS: Calculator (optional).
E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

PAUL, D.; PEIRCE, D. and STIEF, K. **Electricity.** Toronto: Holt, Rinehart and Winston of Canada Limited, 1976, pp. 25-28.

LEARNING ACTIVITIES

THE STUDENT:

3.17.1 Identifies the information needed to solve a problem.

3.17.2 Identifies the appropriate unit of measurement for the physical quantities used in each problem.

3.17.3 Uses mathematical operators correctly when solving a problem.

3.17.4 Verifies that the answer is plausible, using unit analysis.

3.17.5 Verifies that the answer is plausible by calculating the order of magnitude.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

** 3.18 Verify the solutions to the numerical problems in 3.15, 3.16, or 3.17 by means of an experiment.

PREREQUISITES:

3.9, 3.10, 3.15, 3.16 or 3.17

RELATED CONTENT:

- SKILL: Measuring. (B-3)
- KNOWLEDGE: Ability to conduct experiments to test laws. (A-8)
- ATTITUDE: Critical attitude. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Laboratory work, class discussion.
B. DURATION: (100/150) minutes.
C. EVALUATION: Student's ability to think critically.
D. MATERIALS: Materials, tools, instruments and equipment needed to conduct experiments based on the problems in 3.15, 3.16, 3.17.
E. SAFETY MEASURES: Precautions in handling lab materials and equipment.

SUGGESTED REFERENCES:

LEARNING ACTIVITIES

THE STUDENT:

3.18.1 Measures the physical quantities associated with the problems in 3.15, 3.16, and 3.17, using appropriate measuring instruments.

3.18.2 Compares his/her measurements with the calculated results.

3.18.3 Formulates explanations for the difference between the measured and calculated results.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

4. **Determine the amount of electric energy consumed by a circuit, using techniques with which he/she has become familiar.**

   4.1 Determine the cost of using an electrical appliance.

PREREQUISITES:

RELATED CONTENT:

- SKILL:	Interpreting data. (D-3)
- KNOWLEDGE:	Characteristics of electrical appliances: power, voltage, current, frequency. $E = pt$. (A-2)
- ATTITUDE:	Willingness to interpret information. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:	Group work, brainstorming.
B. DURATION:	(90/75) minutes.
C. EVALUATION:	Student's methods of calculation.
D. MATERIALS:	Reference materials, electrical appliances, electricity bills.
E. SAFETY MEASURES:	None.

SUGGESTED REFERENCES:

PAUL, D.; PEIRCE, D. and STIEF, K. **Electricity.** Toronto: Holt, Rinehart and Winston of Canada Limited, 1976, p. 31, section on the cost of electric energy.

Video: **La facture d'Hydro-Québec**, 11 min, Hydro-Québec, 1988, (U-0626).

LEARNING ACTIVITIES

THE STUDENT:

4.1.1 Lists technical objects in his/her environment that transform electrical energy into other forms of energy.

4.1.2 Identifies the different characteristics of an electrical appliance by examining its rating plate.

4.1.3 Associates one of the characteristics of an electrical appliance with a parameter on a Hydro-Québec electricity bill.

4.1.4 Estimates the cost of using electrical appliances over a given period of time.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and intermediate)

THE STUDENT WILL BE ABLE TO:

* 4.2 Define the unit for measuring electric current, after observing a demonstration.

PREREQUISITES:

3.3

RELATED CONTENT:

- SKILL: Observing. (B-1)
- KNOWLEDGE: Concept of an electric current, unit of electric charge, unit of electric current. (A-4)
- ATTITUDE: Intellectual curiosity. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY: Brainstorming, presentation, demonstration, class discussion, individual work.
B. DURATION: 60 minutes.
C. EVALUATION: Student's understanding of the concept of an electric current.
D. MATERIALS: Electrostatic generator, plates, conducting wire, electrostatic pendulum.
E. SAFETY MEASURES: Precautions to avoid electric shocks.

SUGGESTED REFERENCES:

AMPÈRE, André Marie. **Extraits de Mémoire de l'action exercée sur un courant électrique par un autre courant, le globe terrestre ou un aimant**, présentés par Louis Poudensen, Paris, Gauthier-Villars, 1964, 94 p.

Brochure: **Guide SI**, Hydro-Québec, 1982, 142 p.

*Video: **ELECTRICITY SERIES**, TV Ontario, one 10-minute program: **4. Current Electricity.**

LEARNING ACTIVITIES

THE STUDENT:

4.2.0 Recalls the concept of an electric charge. (Module 1-4.4).

4.2.1 Suggests his/her conception of an electric charge.

4.2.2 Suggests a way of measuring electric current in units of electric charge, after observing a demonstration.

4.2.3 Becomes aware of the unit used to measure an electric charge.

4.2.4 Associates the concept of electric current with a flow of electric charges.

4.2.5 Becomes aware of the physicist's definition of an electric current of one ampere.

4.2.6 Illustrates the importance of the work of André-Marie Ampère, showing how it is applied to modern technology.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and intermediate)

THE STUDENT WILL BE ABLE TO:

* 4.3 Define the unit of measure for electrical potential difference, after conducting an experiment.

PREREQUISITES:

3.4, 4.2

RELATED CONTENT:

- SKILL: Generalizing. (D-6)
- KNOWLEDGE: Concept of potential difference. (A-3)
- ATTITUDE: Willingness to synthesize and apply knowledge. (I-1)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY: Brainstorming, group work, laboratory work, class discussion, individual work.

B. DURATION: 90 minutes in class + work at home.

C. EVALUATION: Student's reasoning.

D. MATERIALS: Reference materials, batteries, light bulbs, conducting wire, ammeter, resistors, scale of luminosity, graph paper.

E. SAFETY MEASURES: Precautions for handling lab materials and equipment.

SUGGESTED REFERENCES:

*Video: **ELECTRICITY SERIES**, TV Ontario, one 10-minute program: **5. Potential Difference.**

LEARNING ACTIVITIES

THE STUDENT:

4.3.1 Formulates a hypothesis regarding the potential difference across several batteries connected in series.

4.3.2 Tests that hypothesis by means of an experiment.

4.3.3 Formulates a hypothesis regarding the current in an electric circuit of known resistance consisting of several batteries connected in series.

4.3.4 Tests that hypothesis by means of an experiment.

4.3.5 Demonstrates that the potential difference applied to the terminals of an electric circuit is proportional to the resistance of the circuit when the current is constant, using a suggested procedure.

4.3.6 Associates the increase in the amount of energy used in the circuit with the increase in potential difference when the current is constant.

4.3.7 Associates electric current with the number of electric charges per unit of time.

4.3.8 Associates potential difference with the energy used per unit of electric charge.

4.3.9 Shows that the potential difference can be expressed in joules per coulomb.

4.3.10 Shows how Alessandro Volta's invention of the battery contributed to the widespread application of electromagnetic principles in the nineteenth century.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and intermediate)

THE STUDENT WILL BE ABLE TO:

4.4 Identify the units that define electric energy, using the variables associated with electric circuits.

PREREQUISITES:

3.3, 3.4

RELATED CONTENT:

- SKILL:	Interpreting data. (D-3)
- KNOWLEDGE:	Variables used to calculate electric energy, units of electric energy. (A-4)
- ATTITUDE:	Willingness to synthesize and apply knowledge. (I-4)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Brainstorming, presentation, group work, class discussion.

B. DURATION:	(75/100) minutes.
C. EVALUATION:	Student's knowledge of the different units of electric energy.
D. MATERIALS:	Hydro-Québec bill, reference materials.
E. SAFETY MEASURES:	None.

SUGGESTED REFERENCES:

HIRSCH, A. **Physics: A Practical Approach.** Toronto: John Wiley and Sons, 1981, pp. 322-326, section on the cost of electric energy.

LEARNING ACTIVITIES

THE STUDENT:

4.4.0 Recalls the concept of energy (Ecology 114, Physical Sciences 21 , Human Biology 314).

4.4.1 Suggests his/her conception of electric energy.

4.4.2 Becomes aware of the SI (International System of Units) unit used to measure electric energy.

4.4.3 Suggests a way of calculating the electric energy used by a circuit element by establishing a mathematical relationship between the following physical quantities: potential difference, electric current, and time.

4.4.4 Determines a unit of electric energy, using that mathematical relationship.

4.4.5 Compares his/her proposal with those of the other students.

4.4.6 Associates a unit of energy with the parameters used by Hydro-Québec.

4.4.7 Establishes an equivalence relation involving the following units of energy: joule (J), volt-ampere-seconds, (V-A-S), watt-seconds (W-s), kilowatt-hours (k-W-h).

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

* 4.5 Justify the use of high tension wires to transport electrical energy.

PREREQUISITES:

4.2, 4.3, 4.4

RELATED CONTENT:

-	SKILL:	Generalizing. (F-1)
-	KNOWLEDGE:	Joule effect, Joule's law. (A-8)
-	ATTITUDE:	Critical attitude. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Group work, individual work.
B. DURATION: 60 minutes.
C. EVALUATION: Student's understanding of Joule's law.
D. MATERIALS: None.
E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

Brochure: **Le point sur les effets des lignes à haute tension**, Hydro-Québec, 1983, 55 p.

Videos:
- **High Performance Crossing**, 24 min, Hydro-Québec, 1986.
- **At 735 Kv, Liveline Work**, 18 min, Hydro-Québec, 1974.
- **Synchronous Condensers**, 22 min, Hydro-Québec, 1973.

LEARNING ACTIVITIES

THE STUDENT:

4.5.0 Recalls Ohm's law (3.5, 3.6).

4.5.1 Proposes a mathematical relationship between the electrical power dissipated by a conductor and the resistance of that conductor.

4.5.2 Determines the electric current flowing through a conductor as the potential difference increases, given a certain amount of electrical power.

4.5.3 Calculates the electrical power dissipated by the conductor at varying levels of potential difference.

4.5.4 Demonstrates, through calculations, that the energy dissipated by the conductor decreases as the potential difference increases, given a certain amount of electrical power.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

- • 4.6 Solve numerical problems that involve calculating the electric energy used in a circuit.

PREREQUISITES:

4.1, 4.2, 4.3, 4.4, 4.5

RELATED CONTENT:

- SKILL: Interpreting data. (D-1)
- KNOWLEDGE: Numerical exercises dealing with electric energy, Joule's law, cost of electric energy. (A-8)
- ATTITUDE: Willingness to interpret information. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Group work, individual work.
B. DURATION: 100 minutes in class + work at home.
C. EVALUATION: Student's methods of calculation.
D. MATERIALS: Calculator (optional).
E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

LEARNING ACTIVITIES

THE STUDENT:

4.5.1 Identifies the information needed to solve a problem.

4.6.2 Identifies the appropriate unit of measurement for each variable in the problem.

4.6.3 Uses mathematical operators correctly when solving a problem.

4.6.4 Verifies that the answer is plausible, using unit analysis.

4.6.5 Verifies that the answer is plausible by calculating the order of magnitude.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

5. **Demonstrate the law of conservation of energy with which he/she has become familiar while doing laboratory experiments.**

   5.1 Determine the amount of energy used by a resistor, by conducting an experiment.

PREREQUISITES:

3.3, 3.4, 4.4

RELATED CONTENT:

- SKILL: Developing an experimental procedure. (C-4)
- KNOWLEDGE: Electric energy used by a resistor. (A-1)
- ATTITUDE: Intellectual curiosity. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Group work, laboratory work, individual work.
B. DURATION: (75/100) minutes in class + work at home.
C. EVALUATION: Accuracy of measurements.
D. MATERIALS: Power supply, resistor, ammeter, voltmeter, conducting wire, chronometer.
E. SAFETY MEASURES: Precautions in handling lab materials and equipment.

SUGGESTED REFERENCES:

HIRSCH, A. Physics: A **Practical Approach**
Toronto: John Wiley and Sons, 1981,
pp. 319-321.

LEARNING ACTIVITIES

THE STUDENT:

5.1.1 Develops a procedure for determining the amount of electric energy used by a resistor.

5.1.2 Carries out a laboratory experiment.

5.1.3 Writes a report on the experiment he/she has conducted.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

5.2 Calculate heat energy, using a mathematical relationship.

PREREQUISITES:

Physical Sciences 214, Human Biology 314.

RELATED CONTENT:

- SKILL: Interpreting data. (D-3)
- KNOWLEDGE: Ability to calculate heat energy. $(Q = m \Delta TCp)$. (A-8)
- ATTITUDE: Critical attitude. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY: Demonstration, group work, presentation, laboratory work, individual work.

B. DURATION: (75/100) minutes in class + work at home.

C. EVALUATION: Student's methods of calculation.

D. MATERIALS: Reference material, reference manual, calorimeter, thermometer, balance, conducting wire, power supply, nickel and chrome wire, ringstands.

E. SAFETY MEASURES: Heating.

SUGGESTED REFERENCES:

SPENCER, P.; McNEILL, K. and MACLACHLAN, J. **Matter and Energy.** Richmond Hill, Ont.: Irwin Publishing Inc., 1978, pp. 270-271.

LEARNING ACTIVITIES

THE STUDENT:

5.2.0 Recalls the concepts of heat and temperature and the phenomenon of expansion (Physical Sciences 214, Module on heat and thermal effects).

Recalls characteristic properties of matter (Module 1-2).

5.2.1 Observes, during a demonstration, what happens when a current-bearing conductor is elongated.

5.2.2 Associates the elongation of the conductor with the production of heat energy.

5.2.3 Suggests factors that can determine the amount of heat energy absorbed or transferred by a substance.

5.2.4 Becomes aware of the mathematical relationship between the factors that determine the amount of heat energy absorbed or transferred by a substance.

5.2.5 Associates specific heat with a characteristic property of matter.

5.2.6 Finds the specific heat (s) of given substances by consulting a reference manual.

5.2.7 Verifies that the mathematical relationship is plausible by analyzing the units used to quantify physical quantities associated with heat energy.

5.2.8 Determines the amount of heat energy absorbed or transferred by a substance when energy is transformed.

5.2.9 Explains James Watt's role in the Industrial Revolution.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

5.3 Analyze the transformation of electric energy into heat energy, based on measurements and calculations.

PREREQUISITES:

5.1, 5.2

RELATED CONTENT:

-	SKILL:	Generalizing. (F-1)
-	KNOWLEDGE:	Law of conservation of energy. (A-8)
-	ATTITUDE:	Conscientiousness. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Group work, laboratory work, class discussion, individual work.

B.	DURATION:	(125/150) minutes in class + work at home.
C.	EVALUATION:	Student's laboratory work.
D.	MATERIALS:	Power supply, electric resistance calorimeter, resistor, ammeter, voltmeter, chronometer, thermometer, balance, reference materials.
E.	SAFETY MEASURES:	Precautions in handling lab materials and equipment.

SUGGESTED REFERENCES:

16 mm Film: **Electrical Potential Energy, Part II**, 27 min, Ward's Natural Science Establishment.

LEARNING ACTIVITIES

THE STUDENT:

5.3.1 Develops a procedure for measuring the amount of electric energy transformed into heat energy by a circuit element.

5.3.2 Carries out a laboratory experiment.

5.3.3 Formulates a law of conservation of energy on the basis of experimental results.

5.3.4 Compares his/her law with those of the other students.

5.3.5 Formulates hypotheses to explain any errors.

5.3.6 Formulates hypotheses regarding the conservation of energy during other transformations.

5.3.7 Describes some of the major discoveries of physicist James Prescott Joule.

5.3.8 Lists technical objects whose function is to transform electric energy into heat energy.

5.3.9 Writes a report on the experiment he/she has conducted.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

* 5.4 Solve numerical problems that require the student to apply the law of conservation of energy to situations in which electric energy is being transformed into heat energy.

PREREQUISITES:

5.3

RELATED CONTENT:

- SKILL: Interpreting data. (D-1)
- KNOWLEDGE: Procedure for calculating electric and heat energy. (A-7)
- ATTITUDE: Willingness to interpret information. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Group work, individual work.
B. DURATION: 50 minutes in class + work at home.
C. EVALUATION: Student's methods of calculation.
D. MATERIALS: Calculator (optional).
E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

VERWIEBE, F. and HOOFT, J. **Basic Physics - Lab Manual.** Nostrand Company of Canada, 1964, pp. 136-137, section on electrical energy equivalent of heat energy.

LEARNING ACTIVITIES

THE STUDENT:

5.4.1 Identifies the information needed to solve a problem.

5.4.2 Identifies the appropriate unit of measurement for each variable in the problem.

5.4.3 Uses mathematical operators correctly when solving a problem.

5.4.4 Verifies that the answer is plausible, using unit analysis.

5.4.5 Verifies that the answer is plausible by calculating the order of magnitude.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

** 5.5 Identify technological applications of the law of conservation of energy in his/her environment.

PREREQUISITES:

5.3

RELATED CONTENT:

- SKILL: Observing. (B-1)
- KNOWLEDGE: Applications of the law of conservation of energy. (A-10)
- ATTITUDE: Sense of responsibility (concern for the environment). (I-4)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Brainstorming, field trip, group work, individual work, class discussion.
B. DURATION: (50/75) minutes in class + work at home.
C. EVALUATION: Student's description.
D. MATERIALS: Reference materials.
E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

GAGNON, Luc, Yves Guérard. "Énergie: La trilogie du gaspillage", **Franc Nord**, hiver 1988, pp. 23-25.

LEARNING ACTIVITIES

THE STUDENT:

5.5.1 Lists consumer goods that transform energy.

5.5.2 Associates with each consumer good the forms of energy involved.

5.5.3 Describes the energy transformations brought about by these consumer goods.

5.5.4 Formulates hypotheses regarding the reasons for energy loss during transformations.

5.5.5 Suggests ways of reducing energy loss during transformations brought about by these consumer goods.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

6. **Make an environmental impact study of certain types of energy transformations.**

6.1 Show how electric energy is transformed into other forms of energy, by conducting an experiment.

PREREQUISITES:

3.11, 3.12, 4.1

RELATED CONTENT:

- SKILL: Observing. (B-2)
- KNOWLEDGE: Examples of the transformation of energy. (A-3)
- ATTITUDE: Creative approach. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Brainstorming, individual work, laboratory work.
B. DURATION: (125/125) minutes.
C. EVALUATION: Student's knowledge of different types of energy transformations.
D. MATERIALS: Power supply, conducting wire, different devices depending on the type of transformation involved.
E. SAFETY MEASURES: Precautions in handling lab materials and equipment, heating, chemical substances.

SUGGESTED REFERENCES:

16 mm Film: **Learning About Electric Current**, 15 min, Britannica Learning Materials.

LEARNING ACTIVITIES

THE STUDENT:

6.1.1 Lists the uses of energy in his/her environment.

6.1.2 Draws a circuit diagram illustrating an energy transformation.

6.1.3 Assembles this circuit.

6.1.4 Describes the effects that he/she observed as the various elements of the circuit transformed energy.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

6.2 Describe methods of producing electric energy, after observing his/her environment.

PREREQUISITES:

3.11, 3.12

RELATED CONTENT:

- SKILL: Observing. (B-2)
- KNOWLEDGE: Methods of producing electricity. (A-1)
- ATTITUDE: Intellectual curiosity. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Field trip, brainstorming, individual work, laboratory work.
B. DURATION: (75/100) minutes in class + work at home.
C. EVALUATION: Student's description.
D. MATERIALS: Reference materials related to the suggested circuit.
E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

Videos:

*- **About Science Series**, TV Ontario, Tape 7, 23 min.
- **Electricité d'origine nucléaire**, 1975, 13 min, N.F.B.
- **Nuclear Power Demonstration**, 30 min, Crawley, N.F.B.
- **Power in Perpetuity**, 20 min 53 sec, 1967, N.F.B.

LEARNING ACTIVITIES

THE STUDENT:

6.2.1 Identifies the ways in which electric energy is produced in his/her environment.

6.2.2 Describes the energy transformation process associated with each method of producing electricity.

6.2.3 Lists the advantages and disadvantages of each method of producing electric energy.

6.2.4 Produces electric energy, using a circuit he/she has designed.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

6.3 Analyze the environmental impact of various methods of producing electric energy.

PREREQUISITES:

6.2

RELATED CONTENT:

- SKILL: Generalizing. (F-3)
- KNOWLEDGE: Impact of the production of electricity. (A-1)
- ATTITUDE: Sense of responsibility (concern for the environment). (I-4)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Brainstorming, group work, individual work, class discussion.
B. DURATION: (50/75) minutes in class + work at home.
C. EVALUATION: Student's argumentation.
D. MATERIALS: Reference materials.
E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

Videos:
- **Challenge Net** (A), 25 min, Hydro-Québec, 1983.
- **L'Hydro-électricité**, 21 min, Radio-Canada.
- **Le vent domestiqué**, 1978, 13 min, N.F.B.

LEARNING ACTIVITIES

THE STUDENT:

6.3.1 Identifies how various methods of producing electric energy are beneficial or harmful to the environment.

6.3.2 Assesses the environmental and social impact of various methods of producing electric energy.

6.3.3 Suggests ways of minimizing the negative environmental impact of the production of electricity.

6.3.4 Assesses the economic feasibility of the methods suggested.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and intermediate)

THE STUDENT WILL BE ABLE TO:

** 6.4 Analyze the state of research into energy transformation techniques.

PREREQUISITES:

6.2

RELATED CONTENT:

- SKILL: Generalizing. (F-3)
- KNOWLEDGE: Energy transformation techniques. (A-1)
- ATTITUDE: Intellectual curiosity. (H-5)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Individual work, brainstorming, group work.
B. DURATION: (50/75) minutes in class + work at home.
C. EVALUATION: Library research methods.
D. MATERIALS: Reference materials.
E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

CABANAT, Martine. **Les Énergies renouvelables.** Paris, Hachette, 1981, 64 p., (collection En savoir plus).

DOROZYNSKI, Alexandre. "Le "Frigo" à chaleur", **Science et vie**, N° 843, (décembre 1987), pp. 106-107.

LANDRY, Louis. "Le chauffage par la chaleur humaine", **Vidéo-presse**, N° 2, (octobre 1987).

Slide tape presentations:
- **L'électricité à tout vent**, 15 min, Hydro-Québec, 1983, (D-0429).
- **Electricité nouvelle**, 23 min, Hydro-Québec, 1981, (D-0426).
- **Energie du soleil**, 17 min, Hydro-Québec, 1980, (D-0427).
- **Energie verte**, 15 min, Hydro-Québec, 1980, (D-0428).

16 mm Film and Video: - **Les énergies douces, 25 min, Radio-Canada.**

LEARNING ACTIVITIES

THE STUDENT:

6.4.1 Becomes familiar with the state of research into the use of new sources of energy.

6.4.2 Predicts how the use of new sources of energy will affect the environment.

6.4.3 Lists the forms of energy that cannot be transformed efficiently with current technology.

6.4.4 Identifies Québec's contribution to the development of energy transformation techniques.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and intermediate)

THE STUDENT WILL BE ABLE TO:

** 6.5 **Analyze the possibility of bringing about the perpetual transformation of energy.**

PREREQUISITES:

5.3, 6.1, 6.2

RELATED CONTENT:

- SKILL: Formulating hypotheses. (C-2)
- **KNOWLEDGE:** Concept of the dissipation of energy. (A-8)
- ATTITUDE: Objectivity. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Laboratory work, individual work, presentation, class discussion.
B. DURATION: (125/150) minutes.
C. EVALUATION: Quality of discussion.
D. MATERIALS: Reference materials, lab materials and equipment needed for a given experiment.
E. SAFETY MEASURES: Depending on equipment and materials used.

SUGGESTED REFERENCES:

DOSSIER: "Le mouvement perpétuel", **Sciences et Vie Junior**, (mars 1989), N° 2, p. 60 à 69.
TIERNEY, John. "Perpétuel commotion", **Science 83**, (mai 1983), pp. 30-39.

LEARNING ACTIVITIES

THE STUDENT:

6.5.1 Suggests a way of bringing about successive and perpetual energy transformations based on the law of conservation of energy (e.g., electrical-thermal-electrical).

6.5.2 Verifies the suggested method, if possible.

6.5.3 Becomes aware of the history of attempts to design a system to bring about perpetual energy transformations.

6.5.4 Becomes aware of scientists' opinions regarding perpetual energy transformations.

6.5.5 Discusses how energy is dissipated during transformations.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and intermediate)

THE STUDENT WILL BE ABLE TO:

7. **Make a study of how electrification has affected Québec society.**

    7.1 Describe the importance of energy in the daily lives of Quebecers.

PREREQUISITES:

4.1, 4.2

RELATED CONTENT:

- SKILL: Interpreting data. (D-4)
- **KNOWLEDGE:** Energy needs. (A-1)
- ATTITUDE: Intellectual curiosity. (H-5)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Presentation, individual work, group work, class discussion.
B. DURATION: (50/75) minutes in class + work at home.
C. EVALUATION: Student's ability to gather information.
D. **MATERIALS:** Reference materials.
E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

BOLDUC, André, C. Hogue et D. Larouche. **Québec, un siècle d'électricité**, Montréal, Editions Libre Expression, 1984, 440 p.

Educational Software: **Energie**, Denys St-Denis, Télémax Data Inc., Sonovision Inc., Montréal, 1986.

LEARNING ACTIVITIES

THE STUDENT:

7.1.0 Recalls the definitions of a physical change and a chemical change (Module 1-3.2).

7.1.1 Identifies changes that create a need for energy.

7.1.2 Distinguishes between sources of energy used in a non-industrial society and those used in an industrial society.

7.1.3 Distinguishes between the amount of energy needed in a non-industrial society and the amount required in an industrial society.

7.1.4 Estimates Québec's per capita energy needs.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

7.2 Identify the major steps in the development of Québec's electrical power network.

PREREQUISITES:

RELATED CONTENT:

- SKILL: Generalizing. (F-3)
- KNOWLEDGE: History of the electrification of Québec. (A-1)
- ATTITUDE: Sense of belonging. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Field trips, individual work, group work, presentation, class discussion.
B. DURATION: (50/75) minutes in class + work at home.
C. EVALUATION: Student's research methods.
D. MATERIALS: Reference materials.
E. SAFETY MEASURES: Safety precautions to be taken during field trips.

SUGGESTED REFERENCES:

PÉPIN, Reynald. "Le réseau hydro-québécois: un géant aux pieds d'argile?", **Québec Science**, vol. 22, n° 5, (janvier 1984), p. 20 à 26.
RIENDEAU, Roger. "Les autoroutes de l'énergie: une incision dans l'environnement", **Forêt-Conservation**, vol. 55, n° 4, (octobre 1988), p. 18 à 22.
Brochures: - **Le réseau**, Hydro-Québec, 1986, 40 p., (983-2546).
- **Les centres d'exploitation régionaux**, Hydro-Québec, 1987, 32 p., (983-2227).
Map: **Production et transport d'énergie** (carte thématique), 115 x 145 cm, Hydro-Québec, 1987, (983-1698).
Pamphlet: **Le réseau d'Hydro-Québec, en 1987**, 18 x 28 cm, Hydro-Québec, 1987, (D-88-0027).
Slide tape presentation: - **Vingt-cinq ans d'essais en réseau à Hydro-Québec**, 16 min, Hydro-Québec, 1985, (D-2547).
Videos: - **T'as de l'électricité dans l'air**, 22 min, Hydro-Québec, 1977, (F-0161).
- **Le réseau**, 20 min, Hydro-Québec, 1979, (F-0156).
- **Lic et Lec**, 11 min, Hydro-Québec, 1983, (F-0159).
- **Beauharnois, au fil du temps**, 15 min, Hydro-Québec, 1981, (F-0002).
- **Bersimis**, 24 min, Hydro-Québec, 1959, (F-0416, archives).
- **Bienvenue à Carillon**, 11 min, Hydro-Québec, 1978, (F-0115, archives).

LEARNING ACTIVITIES

THE STUDENT:

7.2.0 Recalls the aspects of the development of Québec's electrical power network that were studied in the Québec history and geography programs.

7.2.1 Identifies the elements of the electrical power network in his/her environment.

7.2.2 Assesses the size of the electrical power network in his/her region in relation to the provincial network.

7.2.3 Becomes aware of the major steps in the development of the electrical power network in his/her region by consulting reference materials.

7.2.4 Compares the development of the electrical power network in his/her region with the development of the provincial network.

7.2.5 Assesses the impact of the electrical power network on the environment in his/her region.

7.2.6 Identifies scientists, industrialists, and politicians who contributed to the development of Québec's electrical power network.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

** 7.3 Analyze the relationship between scientific and technological discoveries pertaining to electricity and the development of Québec's electrical power network.

PREREQUISITES:

7.2

RELATED CONTENT:

-	SKILL:	Generalizing. (F-3)
-	KNOWLEDGE:	Scientific and technological discoveries related to electricity. (A-10)
-	ATTITUDE:	"Constructivist" view of science. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Individual work, group work, class discussion.

B.	DURATION:	(50/75) minutes in class + work at home.
C.	EVALUATION:	Student's ability to associate scientific discoveries and technological applications with specific steps in the development of Québec's electrical power network.
D.	MATERIALS:	Reference materials.
E.	SAFETY MEASURES:	None.

SUGGESTED REFERENCES:

Brochure:	**Le redresseur-onduleur de Châteauguay.** Hydro-Québec, 1986, 20 p., (086-0021).
Bulletin:	**Information TAI**, mai, septembre, décembre, Hydro-Québec, 1988-1989.
Video:	**Nostalgie Volume 4, Modernisme au Québec au milieu du XXe siècle**, 58 min, (La Vallée des dynamo), 1955, N.F.B.

LEARNING ACTIVITIES

THE STUDENT:

7.3.1 Identifies scientific discoveries that contributed to the development of Québec's electrical power network.

7.3.2 Identifies scientific discoveries and technological applications that have resulted from the development of Québec's electrical power network.

7.3.3 Associates these scientific discoveries and technological applications with the major steps in the development of Québec's electrical power network.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal or Intermediate)

THE STUDENT WILL BE ABLE TO:

** 7.4 Analyze how the use of electricity affects the lives of Quebecers.

PREREQUISITES:

7.1

RELATED CONTENT:

- SKILL: Generalizing. (F-3)
- KNOWLEDGE: Uses of electricity. (A-1)
- ATTITUDE: Sense of responsibility (concern for the environment). (I-5)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Brainstorming, individual work, group work, class discussion.
B. DURATION: (30/60) minutes in class + work at home.
C. EVALUATION: Student's argumentation.
D. MATERIALS: Reference materials.
E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

16 mm Film and Video: **Le combat d'Onésime Tremblay**, 58 min, 1985, N.F.B.
Gens d'Abitibi, 116 min, 1978, N.F.B.
Slide Tape Presentation: **A grands flots**, 17 min, Hydro-Québec, 1986, (D-0570).
Videos: **Je gaspille, moi!**, 15 min, Hydro-Québec, 1986, (U-412).
L'énergie oubliée, 25 min, Sept. 18, 1989 edition of show called Première ligne (Radio-Québec).

LEARNING ACTIVITIES

THE STUDENT:

7.4.1 Identifies domestic, industrial, and economic uses of electricity.

7.4.2 Assesses the increase in the production of electricity in Québec over the last 50 years.

7.4.3 Associates the increase in the production of electricity with the uses identified in 7.4.1.

7.4.4 Analyzes how the increase in the production of electricity has affected life in Québec.

7.4.5 Discusses the appropriateness of Québec's use of electrical energy.

7.4.6 Proposes ways of making more effective use of Québec's electrical energy.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

7.5 Describe Québec's role in hydroelectric research and development throughout the world.

PREREQUISITES:

7.2

RELATED CONTENT:

- SKILL: Observing. (B-2)
- KNOWLEDGE: Québec's accomplishments in the field of hydroelectric production. (A-1)
- ATTITUDE: Sense of belonging. (H-6)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Presentation, interviews, field trips, individual work, group work, class discussion.

B. DURATION: (75/100) minutes in class + work at home.

C. EVALUATION: Student's knowledge of Québec's accomplishments in the field of hydroelectric production.

D. MATERIALS: Reference materials.

E. SAFETY MEASURES: Safety precautions to be taken during field trips.

SUGGESTED REFERENCES:

16 mm Film: **Innovations: un dossier sur la technologie canadienne**, 27 min, 1980, N.F.B.

Brochures:
- **Plan de développement d'Hydro-Québec 1988-89, Horizon 1997, Version intégrale**, Hydro-Québec, 1988, 141 p., (D88-0001).
- **Plan de développement d'Hydro-Québec 1988-89, Horizon 1997, Version abrégée**, Hydro-Québec, 1988, 43 p., (D88-0015).
- **Technologies, affaires internationales et Institut de recherche d'Hydro-Québec** (TAI), Rapport d'activité 1987, Hydro-Québec, 1988, 50 p., (D88-0051).

LEARNING ACTIVITIES

THE STUDENT:

7.5.1 Identifies the latest hydroelectric research conducted in Québec, after consulting reference materials.

7.5.2 Identifies Québec high-tech equipment used abroad.

7.5.3 Identifies Québec firms and institutions that have contributed to the development of hydroelectric power facilities throughout the world.

7.5.4 Describes foreign hydroelectric power facilities built by Quebeckers.

7.5.5 Gives examples of Québec's role in training representatives from other countries to become experts in hydroelectric production.

TEACHER'S NOTES:

Module III
Ionic Phenomena

MODULE OBJECTIVE: TO EXPLORE the properties of chemical substances, transformations involving these substances, and the way in which their use affects the environment and the lives of Quebecers, using the scientific method.

SPECIFIC OBJECTIVES
(Terminal and intermediate)

THE STUDENT WILL BE ABLE TO:

1. **Communicate the results of an experimental research project focusing on at least one acid, one base, or one salt, using correct language.**

   1.1 Choose a research topic.

PREREQUISITES:

RELATED CONTENT:

- SKILL: Recognizing a problem. (C-1)
- KNOWLEDGE: Research methods. (A-7)
- ATTITUDE: Fascination with science. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY: individual work, presentation, brainstorming, class discussion.
B. DURATION: (50/50) minutes.
C. EVALUATION: Students' behaviour.
D. MATERIALS: Appropriate reference materials.
E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

Chemical Matters. American Chemical Society, 1155 16th N.W., Washington, D.C.

[illegible], T., POOLE, M. and PACK, D. **Chemicals in Action**. Toronto: Holt, Rinehart and Winston of Canada Ltd., 1987, "Acids and Bases in Action," p. 283; "Acid and Base Indicators at Home," p. 240; "Acids and Bases in Our Environment," p. 245; "Testing for Acids and Bases in 10 Consumer Products," p. 250.

JOLLIFFE, L.; JONES, M.; KILLAM, G. and LYONS, D. **Insights 10**. Mississauga, Ont.: Copp Clark Pitman Ltd., 1982, pp. 90-91.

SHAPIRO, R. and SHAPIRO, S. **Chemistry at Work**. Mississauga, Ont.: Copp Clark Pitman Ltd., 1984, "Common Sense with Acids and Bases," p. 183; "Household Products," p. 190; "Acids and Bases in Action," p. 198; "The pH scale," p. 202; "How pH is used in industry," p. 212; "Acid Rain," p. 214.

Videos: **WHAT ABOUT SERIES**, TV Ontario, two 15-minute tapes: **1. Questioning in Science; 2. Hypothesizing in Science.**

TEACHER'S NOTES:

LEARNING ACTIVITIES

THE STUDENT:

1.1.0 Recalls the steps to be taken in organizing a research project (Module 1-1).

1.1.1 Becomes aware of experimental research topics related to at least one acid, one base, or one salt.

1.1.2 Suggests other experimental research topics related to at least one acid, one base, or one salt.

1.1.3 Chooses one research topic from among those listed in 1.1.1 and 1.1.2.

List of Research Projects
Related to Terminal Objective 1

1- Verifying the effect of an antacid on one or more acidic solutions.
2- Comparing the effectiveness of various antacids.
3- Measuring the pH of precipitation.
4- Monitoring the pH of snow over the course of the winter (precipitation on the ground).
5- Determining how acidic, basic, neutral, and saline solutions affect hair.
6- Determining how acid precipitation affects various types of building materials.
7- Determining how acidic, basic, neutral, and saline solutions affect various types of building materials.
8- Comparing the acidity of different types of shampoo and toothpaste.
9- Determining the turning point of a particular mixture of indicators.
10- Determining how acidic, basic, neutral, and saline solutions affect plant growth.
11- Determining how ionic and covalent solutes affect the melting point of a solution.
12- Showing how an ionic solute and a non-ionic solute of equal concentration affect the freezing point of a solution.
13- Determining the turning point of a vegetable indicator.
14- Determining how the pH of soil is affected by the addition of eggshells, lime, bicarbonate, or another substance.
15- Comparing the pH of commonly-used substances.
16- Measuring the quantity of an acid or a base in a household product in solution, in a food, or in other substances, using the titration procedure.
17- Determining how a base affects animal, vegetable, or mineral oils and fats.

SPECIFIC OBJECTIVES
(Terminal and intermediate)

THE STUDENT WILL BE ABLE TO:

1.2 Develop an experimental procedure.

PREREQUISITES:

1.1

RELATED CONTENT:

- SKILL: Developing an experimental procedure. (C-4)
- KNOWLEDGE: Experimental procedure. (A-7)
- ATTITUDE: Willingness to clarify problems. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Group work, individual work, the teacher meets with each student individually.
B. DURATION: (50/50) minutes in class + work at home.
C. EVALUATION: Student's experimental procedure.
D. MATERIALS: Appropriate reference materials, if necessary.
E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

*Video: **WHAT ABOUT SERIES**, TV Ontario, one 15-minute tape: **3. Observing in Science.**

LEARNING ACTIVITIES

THE STUDENT:

1.2.1 Determines the purpose of the research project.

1.2.2 Draws up a list of reference materials to be used for this project.

1.2.3 Formulates one or more hypotheses, if necessary.

1.2.4 Specifies the tasks involved in the experiments.

1.2.5 Determines the variables to be measured.

1.2.6 Determines the quantities to be kept constant.

1.2.7 Determines a method of recording the data.

1.2.8 Decides on the necessary lab materials.

1.2.9 Draws a diagram of any apparatus used.

1.2.10 Has his/her experimental procedure approved.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

1.3 Carry out the experiment.

PREREQUISITES:

1.2

RELATED CONTENT:

- SKILL: Organizing data. (D-1)
- KNOWLEDGE: Methods and techniques used in scientific work. (A-1)
- ATTITUDE: Intellectual curiosity. (H-5)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Laboratory work, group work, individual work.
B. DURATION: (150/150) minutes + work at home.
C. EVALUATION: Student's methods and techniques.
D. MATERIALS: Depending on the experiment.
E. SAFETY MEASURES: Depending on the experimental research conducted, measures to protect the environment.

SUGGESTED REFERENCES:

*Videos: **WHAT ABOUT SERIES**, TV Ontario, three 15-minute tapes: **4. Measuring in Science; 5. Recording Data in Science; 10. Experimenting in Science.**

LEARNING ACTIVITIES

THE STUDENT:

1.3.1 Sets up any apparatus used in the experiment.

1.3.2 Takes measurements.

1.3.3 Writes down his/her observations.

1.3.4 Compares the results with his/her hypothesis(es).

1.3.5 Modifies his/her hypothesis(es).

1.3.6 Tests his/her new hypothesis(es).

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

1.4 Communicate the results of the experimental research project.

PREREQUISITES:

1.3

RELATED CONTENT:

- SKILL: Communicating. (T-4)
- KNOWLEDGE: Methods and techniques used to produce a research report. (A-4)
- ATTITUDE: Concern for the use of correct language. (T-4)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Group work, individual work.
B. DURATION: [illegible] minutes in class
[illegible]
C. EVALUATION: [illegible] report.
D. MATERIALS: [illegible]
E. SAFETY MEASURES: [illegible]

SUGGESTED REFERENCES:

DORIN, H. **Chemistry: The Study of Matter.** Fairfield, N.J.: Cebeco Standard Publishing, 1982, pp. 3-8.
TREMBLAY, L.M. and [illegible]. **Introduction à la méthode expérimentale.** [illegible], 1970, 116 p.
*video: **WHAT ABOUT SCIENTISTS**, TV Ontario, one 15-minute tape: [illegible]. **Communicating in Science.**

LEARNING ACTIVITIES

THE STUDENT:

1.4.1 States the goal of his/her research project.

1.4.2 Formulates his/her hypothesis(es).

1.4.3 Summarizes the steps in his/her experiments.

1.4.4 Lists the instruments and substances used.

1.4.5 Draws a diagram of any apparatus used for the research project.

1.4.6 Records his/her observations.

1.4.7 Presents numerical data, using tables and graphs.

1.4.8 States his/her conclusions, keeping in mind the purpose of the research project.

1.4.9 Lists reference materials consulted for the research project.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

2. **Explain the properties of acids, bases, and salts that he/she has observed while doing scientific work dealing with various transformations or reactions involving these substances.**

2.1 Identify the properties normally used to classify substances in aqueous solutions as either acids, bases, or neutral salts, after conducting an experiment.

PREREQUISITES:

Module 1-2.

RELATED CONTENT:

- SKILL: Organizing data. (D-1)
- KNOWLEDGE: Common properties of acids, bases, salts. (A-6)
- ATTITUDE: Sense of responsibility (concern for health and safety). (G-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY: Brainstorming, group work, laboratory work, demonstration, class discussion.

B. DURATION: (75/100) minutes.

C. EVALUATION: Student's ability to classify substances.

D. MATERIALS: Test tube, strips of neutral litmus paper, HCl, HCH_3CO_2, NaOH, KOH, NaCl, and $NaNO_3$ solutions (0.5 mol/L or 1 mol/L but not stronger than 0.1 mol/L for testing), citric acid, saturated solution of $Ca(OH)_2$ pieces of Mg, beakers, apparatus used to test electrical conductivity, matches, wooden splints, limewater, 10 mL graduated cylinder, dropper, acidic and basic solutions of equal volume and concentration.

E. SAFETY MEASURES: Neutralizing acids and bases or preserving them for other experiments, precautions for handling glassware and using electricity. As a rule, use the lowest possible concentration of acids and bases. Safety goggles, precautions for testing substances, measures to protect the environment.

SUGGESTED REFERENCES:

SHAPIRO, B. and SHAPIRO, S. **Chemistry at Work.** Mississauga, Ont.: Copp Clark Pitman Ltd., 1989, pp. 187-193.

*Videos: **ABOUT SCIENCE SERIES**, TV Ontario, three 5-minute programs: **9. Conductivity; 10. Acids; 11. Bases and Neutral Compounds.**

LEARNING ACTIVITIES

THE STUDENT:

2.1.1 Identifies ways in which acids, bases, and salts are used in his/her environment.

2.1.2 Suggests definitions for "acid," "base," and "salt," based on his/her knowledge.

2.1.3 Determines the taste and texture of given acidic, basic, and saline solutions, using an appropriate method.

2.1.4 List foods whose properties are similar to those of the solutions examined in 2.1.3.

2.1.5 Determines how the solutions examined in 2.1.3 affect neutral litmus paper.

2.1.6 Determines how the solutions examined in 2.1.3 affect one or more metals.

2.1.7 Identifies the nature of any gases produced in 2.1.6.

2.1.8 Determines whether pure water conducts electricity.

2.1.9 Determines whether the solutions examined in 2.1.3 conduct electricity.

2.1.10 Determines how acids and bases react with each other, after observing a demonstration.

2.1.11 Classifies the solutions examined in 2.1.3 as either acids, bases, or salts, based on their characteristic properties.

2.1.12 Compares his/her classification with the generally accepted classification.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

2.2 Determine the conditions under which substances will exhibit the properties of acids, bases, or salts, after conducting an experiment.

PREREQUISITES:

2.1

RELATED CONTENT:

-	SKILL:	Interpreting data. (D-3)
-	KNOWLEDGE:	Conditions required to observe the properties of acids, bases, and salts. Conductivity of solutes. (A-1)
-	ATTITUDE:	Willingness to compare ideas. (H-3)

SUGGESTED TEACHING PLAN:

A.	TEACHING STRATEGY: Laboratory work,	group work, class discussion.
B.	DURATION:	(50/75) minutes.
C.	EVALUATION:	Student's interpretation.
D.	MATERIALS:	NaCl, $Ca(OH)_2$ and citric acid, strips of neutral litmus paper, apparatus to test electrical conductivity.
E.	SAFETY MEASURES:	Electricity, corrosive substances. Recovering solids for use in subsequent experiments.

SUGGESTED REFERENCES:

SHAPIRO, B. and SHAPIRO, S. **Chemistry at Work.** Mississauga, Ont.: Copp Clark Pitman Ltd., 1989, pp. 198-201.
Video: **Solutions**, 22 min, Coronet.

LEARNING ACTIVITIES

THE STUDENT:

2.2.0 Recalls the role of electrodes in the decomposition of water (Module 1-6.1).

2.2.1 Determines how anhydrous acids, bases, and salts affect litmus paper.

2.2.2 Determines whether the substances examined in 2.2.1 conduct electricity.

2.2.3 Compares the results obtained in 2.2.1 and 2.2.2 with those obtained in 2.1.5 and 2.1.9.

2.2.4 Draws a conclusion based on this comparison.

2.2.5 Suggests an explanation for the electrical conductivity of acids, bases, and salts in aqueous solutions.

2.2.6 Compares his/her explanation with those of the other students.

2.2.7 Compares his/her explanation with the generally accepted explanation.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

2.3 Differentiate among acids, bases, and salts, based on their molecular formulas.

PREREQUISITES:

2.1

RELATED CONTENT:

- SKILL: Interpreting data. (D-3)
- KNOWLEDGE: Definition of an acid, a base, and a salt. (A-3)
- ATTITUDE: Willingness to interpret information. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Group work, simulation, class discussion, presentation.
B. DURATION: (25/50) minutes.
C. EVALUATION: Student's knowledge of a classification of acids, bases, and salts.
D. MATERIALS: None.
E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

Educational Software: **Lowry/Brönsted**, Projet Seraphin, U.Q.T.R.

LEARNING ACTIVITIES

THE STUDENT:

2.3.0 Recalls the method of representing a pure substance (Module 1-6).

2.3.1 Becomes aware of the formulas of the substances used in the solutions examined in 2.1.

2.3.2 Suggests a way of classifying substances as acids, bases, or salts based on those formulas.

2.3.3 Compares his/her classification with those of other students.

2.3.4 Compares his/her classification with the generally accepted classification.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

2.4 Justify the need to produce various acids, bases, and salts, based on their properties and their uses.

PREREQUISITES:

2.1 and 2.3

RELATED CONTENT:

- SKILL:	Generalizing. (F-3)
- KNOWLEDGE:	Use of acids, bases, and salts in ordinary substances. Production of acids, bases, and salts. (A-7)
- ATTITUDE:	Intellectual curiosity. (I-4)

— SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Brainstorming, group work, laboratory work, simulation, individual work.
B. DURATION: (50/75) minutes in class + work at home.
C. EVALUATION: Student's organization of observations.
D. MATERIALS: Reference materials, strips of litmus paper, table to compile the class's results.
E. SAFETY MEASURES: Observance of warnings on product labels.

SUGGESTED REFERENCES:

CLICHE, JEAN-MARIE. "Industrie chimique québécoise," **Spectre**, vol. 18, N° 4, (March 1989), pp. 9-24.
SHAPIRO, B. and SHAPIRO, S. **Chemistry at Work**. Mississauga, Ont.: Copp Clark Pitman Ltd., 1989, pp. 224-243.
Educational Software: **Sulfuric Acid**, Projet Séraphin, UQTR.
Video: **Introducing Chemistry**, 11 min, Coronet.

LEARNING ACTIVITIES

THE STUDENT:

2.4.1 Lists commonly-used substances in his/her environment.

2.4.2 Determines whether the substances listed in 2.4.1 contain an acid, a base, or a salt, based on the product label.

2.4.3 Develops an experimental procedure to verify the information on the labels or his/her predictions if the labels do not provide that information.

2.4.4 Carries out the experiment.

2.4.5 Writes his/her observations in the table used to compile the class's results.

2.4.6 Describes the role and the uses of some of these acids, bases, and salts, after consulting reference materials.

2.4.7 Describes the manufacturing process for acids, bases, and salts, after consulting reference materials.

2.4.8 Describes the history of the production of acids, bases, and salts, after doing some background reading.

2.4.9 Writes a paper on his/her readings.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

* 2.5 Distinguish between ionic and covalent bonds.

PREREQUISITES:

Module 1-3.4, 6.1, Module 3-2.1

RELATED CONTENT:

-	SKILL:	Formulating a hypothesis. (C-2)
-	KNOWLEDGE:	Ionic bond, covalent bond. Charge of metallic and non-metallic ions. (A-3)
-	ATTITUDE:	Creative approach. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Individual work, group work, presentation, class discussion.
B. DURATION: 50 minutes.
C. EVALUATION: Student's explanation.
D. MATERIALS: Reference materials, periodic table.
E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

DONOVAN, T.; POOLE, M. and YACK, D. **Chemicals in Action.** Toronto: Holt, Rinehart and Winston of Canada Limited, 1987, pp. 161-175.

*Videos: **CONCEPTS IN SCIENCE SERIES**, TV Ontario, Tape 5 - **Electron Arrangement and Bonding**, two 10-minute programs: **4. How Atoms Bond; 5. Molecular Substance and Covalent Crystals.**

LEARNING ACTIVITIES

THE STUDENT:

2.5.0 Recalls the concept of energy (Physical Sciences 214, Human Biology 314).

Recalls the concept of valence electrons (Module 1-5.8).

Recalls the octet rule (Module 1-6.2).

Recalls compounds made up of a metal and a non-metal and of two non-metals (Module 1-6.3).

2.5.1 Formulates a hypothesis to explain why energy is required to decompose a compound.

2.5.2 Becomes aware of the nature of the bond between a metal and a non-metal in a compound.

2.5.3 Becomes aware of the nature of the bond between two non-metals in a compound.

2.5.4 Classifies certain substances as either ionic or covalent, based on the nature of the bond involved.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

* 2.6 Write the molecular formula of various compounds, based on the ionic charges involved.

PREREQUISITES:

Module 1-6.1, Module 3-2.2

RELATED CONTENT:

-	SKILL:	Constructing a model. (E-1)
-	KNOWLEDGE:	Method of determining the charge of an ion, an anion, a cation, and a radical. (A-4)
-	ATTITUDE:	Willingness to interpret information. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Group work, individual work, presentation, simulation, class discussion.
B. DURATION: 50 minutes.
C. EVALUATION: Student's understanding of the concept of the radical.
D. MATERIALS: Reference materials, periodic table.
E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

Educational Software:
- **Chemistry: Solutions**, ComPress, Wenworth, NH 03282.
- **Chemistry: Chemical Formulas and Equations**, ComPress, Wenworth, NH 03282.

LEARNING ACTIVITIES

THE STUDENT:

2.6.0 Recalls the atomic model developed by Rutherford and Bohr (Module 1-4.9).

2.6.1 Suggests an explanation for the electrical neutrality of a compound.

2.6.2 Identifies the charge carried by each ion in a simple ionic compound, based on the octet rule, the concept of valence electrons and the principle that compounds are electrically neutral.

2.6.3 Compares his/her proposed explanation with those of the other students.

2.6.4 Becomes familiar with the concept of the radical.

2.6.5 Determines the sign and the magnitude of the charge carried by the radicals, given the formulas of common compounds.

2.6.6 Compares the sign and the magnitude of the charge carried by a radical with the algebraic sum of the charges carried by each of its components.

2.6.7 Suggests the molecular formula for various ionic compounds based on the ionic charges involved.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and intermediate)

THE STUDENT WILL BE ABLE TO:

2.7 Distinguish between electrolytic and non-electrolytic substances, after conducting an experiment.

PREREQUISITES:

2.1

RELATED CONTENT:

- SKILL: Developing an experimental procedure. (C-4)
- KNOWLEDGE: Electrolytes, non-electrolytes, solutes. (A-6)
- ATTITUDE: Conscientiousness. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Presentation, group work, laboratory work, class discussion, individual work.
B. DURATION: (75/100) minutes in class + work at home.
C. EVALUATION: Techniques used in laboratory work.
D. MATERIALS: Apparatus to test electrical conductivity, beakers, sugar, vinegar, alcohol, H_2SO_4, NaOH, and $CaCl_2$ solutions (0.5 mol/L), table to compile the class's results.
E. SAFETY MEASURES: Electric current, corrosive substances, glassware, combustible material, waste disposal.

SUGGESTED REFERENCES:

DORIN, H. **Chemistry: The Study of Matter.** Fairfield, N.J.: Cebeco Standard Publishing, 1982, pp. 434-439.

LEARNING ACTIVITIES

THE STUDENT:

2.7.0 Recalls the concepts of electric charge and direction of current (Module 1-4.5 and Module 2-2.3).

Recalls the fact that it is necessary to add a salt, an acid, or a base to carry out the electrolysis of water. (Module 1-6.1)

2.7.1 Tests pure substances to see if they conduct electricity.

2.7.2 Presents the results of these tests in a data table used to compile the class's results.

2.7.3 Develops an experimental procedure to determine whether a substance dissolved in pure water can conduct electricity.

2.7.4 Presents these experimental results in the table used to compile the class's results.

2.7.5 Associates conductors with electrolytic substances and non-conductors with non-electrolytic substances.

2.7.6 Writes a report on the experiment he/she has conducted.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

* 2.8 Explain the electrolytic property of a solute, using the theory of ionic dissociation.

PREREQUISITES:

2.7

RELATED CONTENT:

- SKILL: Constructing a model. (E-1)
- KNOWLEDGE: Strong and weak electrolytes. (A-9)
- ATTITUDE: Willingness to interpret information. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY: Individual work, demonstration, class discussion.
B. DURATION: 50 minutes.
C. EVALUATION: Student's argumentation.
D. MATERIALS: Power supply, apparatus to test electrical conductivity, beakers, HCl, HCH_3CO_2, NaOH, NaCl solutions (0.5 mol/L), saturated $Ca(OH)_2$ and CuCl solutions.
E. SAFETY MEASURES: Electric current, glassware, corrosive substances, waste disposal.

SUGGESTED REFERENCES:

METCALFE, H.; WILLIAMS, J. and CASTKA, J. **Modern Chemistry.** Toronto: Holt, Rinehart and Winston of Canada Limited, 1986, pp. 317-328.

LEARNING ACTIVITIES

THE STUDENT:

2.8.1 Associates the nature of the bond that links the elements of a compound with the electrolytic property of a solute, using the molecular formula.

2.8.2 Explains the electrolytic property of a solute.

2.8.3 Compares his/her explanation with that of the other students.

2.8.4 Explains the variation in the conductivity of different solutes by giving a demonstration.

2.8.5 Associates strong electrolytes with solutes that are good conductors and weak electrolytes with solutes that are fair conductors, after examining solutions of equal concentration.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

** 2.9 Illustrates the theory of the ionization of matter by referring to technological applications.

PREREQUISITES:

2.7

RELATED CONTENT:

- SKILL: Generalizing. (F-2)
- KNOWLEDGE: Applications of electrolytes, ionizers, deionizers. (A-10)
- ATTITUDE: Sense of responsibility (concern for the environment). (I-4)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Brainstorming, group work, individual work, class discussion.
B. DURATION: (50/75) minutes in class + work at home.
C. EVALUATION: Student's knowledge of the applications of electrolytes.
D. MATERIALS: Reference materials.
E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

Petit Robert Dictionnaire alphabétique et analogique de la langue française.
Dictionnaire du français Plus, C.E.C.
Film Loop: **Ion Exchange**, 4 min, Ward's Natural Science Establishment.

LEARNING ACTIVITIES

THE STUDENT:

2.9.1 Lists technological inventions that involved the use of ionic solutions, after consulting reference materials.

2.9.2 Lists consumer products made by using these technological inventions.

2.9.3 Lists the dangers and drawbacks related to using electricity with ionic solutions.

2.9.4 Lists devices that produce or exchange ions, after consulting reference materials.

2.9.5 Lists the uses of the devices listed in 2.9.4.

2.9.6 Explains the process of electroplating, after doing some background reading on the subject.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

2.10 Analyze how non-neutral salts in an aqueous solution affect litmus paper, after conducting experiments.

PREREQUISITES:

2.3

RELATED CONTENT:

- SKILL: Formulating a hypothesis. (C-2)
- KNOWLEDGE: Acidic and basic salts, explanation for the "behaviour" of these salts, use of these salts. (A-10)
- ATTITUDE: "Constructivist" view of science. (I-4)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Presentation, group work, laboratory work, class discussion.
B. DURATION: (50/75) minutes.
C. EVALUATION: Student's hypothesis.
D. MATERIALS: Test tubes, strips of neutral litmus paper, Na_2CO_3, $NaHCO_3$, and $Al_2(SO_4)_3$ solutions (0.5 mol/L).
E. SAFETY MEASURES: Corrosive substances, glassware, measures to protect the environment.

SUGGESTED REFERENCES:

DORIN, H. **Chemistry: The Study of Matter**. Fairfield, N.J.: Cebeco Standard Publishing, 1982, pp. 484-485.

LEARNING ACTIVITIES

THE STUDENT:

2.10.1 Becomes aware of the molecular formulas of salts used to prepare given solutions.

2.10.2 Predicts the effect of the given solutions on neutral litmus paper.

2.10.3 Verifies his/her predictions.

2.10.4 Identifies the ways in which these salts are used.

2.10.5 Formulates a hypothesis to explain the paradoxical "behaviour" of these salts.

2.10.6 Compares his/her hypothesis with those of the other students.

2.10.7 Discusses the merits of a scientific theory.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

** 2.11 Compare the different definitions of an acid and a base by examining the different theories developed by chemists over the years.

PREREQUISITES:

2.1 and 2.3

RELATED CONTENT:

- SKILL:	Generalizing. (D-6)
- KNOWLEDGE:	Various theories about acids and bases (Lavoisier's theory, Arrhenius' theory, the Bronsted-Lowry theory), application of a theory. (A-8)
- ATTITUDE:	"Constructivist" view of science. (I-1)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:	Individual work, group work.
B. DURATION:	(50/75) minutes in class + work at home.
C. EVALUATION:	Student's report.
D. MATERIALS:	Reference materials.
E. SAFETY MEASURES:	None.

SUGGESTED REFERENCES:

METCALFE, H.; WILLIAMS, J. and CASTKA, J. **Modern Chemistry.** Toronto: Holt, Rinehart and Winston of Canada Limited, 1986, pp. 340-358.

16 mm Film: **Acid Base Indicators.** 19 min, Ward's Natural Science Establishment.

*Videos: **ABOUT SCIENCE SERIES.** TV Ontario, two 5-minute programs: **10. Acids; 11. Bases and Neutral Compounds.**

LEARNING ACTIVITIES

THE STUDENT:

2.11.1 Lists scientists who have contributed to the development of theories about acids and bases, after consulting appropriate reference materials.

2.11.2 Associates each scientist with his/her definition of an acid and a base.

2.11.3 Identifies arguments used to accept, reject, or clarify theories, after consulting reference materials.

2.11.4 Concludes that different scientists often put forward the same idea at the same time.

2.11.5 Writes a report on his/her readings.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and intermediate)

THE STUDENT WILL BE ABLE TO:

3. **Analyze variables associated with the aqueous solutions (kept at a constant temperature) that he/she used while doing scientific work.**

   3.1 Prepare an aqueous solution of a given concentration.

PREREQUISITES:

RELATED CONTENT:

- SKILL: Measuring. (G-1)
- KNOWLEDGE: Concentration (g/L, %), concentration units, sequencing of solutions based on their concentrations, preparing a solution. (A-7)
- ATTITUDE: Conscientiousness. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Brainstorming, group work, laboratory work, simulation, class discussion.
B. DURATION: (75-100) minutes.
C. EVALUATION: Student's solution.
D. MATERIALS: water, coloured solute, balloon, stopper, graduated cylinder, standard solutions, balance (+/- 0,01g), weighing boat, labels. Solutions prepared at this point should be preserved so they can be used in Objective 3.2.
E. SAFETY MEASURES: Glassware, recovering solutes.

SUGGESTED REFERENCES:

ORD, D. **Exploring Chemistry.** Hightstown, N.J.: McGraw-Hill Ryerson Ltd., 1986, p. 231, section on volumetric analysis.
Educational Software: **Chemistry: Solutions**, ComPress, Wenworth, NH 03282.
*Videos: **CONCEPTS IN SCIENCE SERIES**, TV Ontario, Tape [illegible]
- The Mole Concept, two 10-minute programs:
1. Relative Mass; 6. The Mole.

LEARNING ACTIVITIES

THE STUDENT:

3.1.0 Recalls the concepts of solute, solvent, and solution (Physical Sciences 214).

3.1.1 Lists examples of solutions commonly used in the home, in food, in pharmaceutical and industrial production, and in other areas.

3.1.2 Identifies the units used to measure the concentrations of the solutions listed in 3.1.1.

3.1.3 Justifies the use of these units.

3.1.4 Arranges the concentrations of different solutions in increasing or decreasing order.

3.1.5 Develops an experimental procedure for preparing a specific volume of a solution of a given concentration.

3.1.6 Carries out the experiment.

3.1.7 Compares his/her solution with the standard solution.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

3.2 Dilute a solution of known concentration to a given concentration.

PREREQUISITES:

3.1

RELATED CONTENT:

- SKILL: Measuring. (G-1)
- KNOWLEDGE: Dilution, relationship between the volume and the concentration of a solution. (A-7)
- ATTITUDE: Conscientiousness. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Brainstorming, group work, laboratory work, class discussion.
B. DURATION: (75/100) minutes.
C. EVALUATION: Student's solution.
D. MATERIALS: Solutions prepared in 3.1, water, graduated cylinder or pipette, container of the same shape and size as the one used for the standard solution, standard solutions.
E. SAFETY MEASURES: Glassware, recovering solutes.

SUGGESTED REFERENCES:

ORD, D. **Exploring Chemistry.** Hightstown, N.J.: McGraw-Hill Ryerson Ltd., 1986, pp. 194-195.

LEARNING ACTIVITIES

THE STUDENT:

3.2.1 Lists examples of common diluted solutions used in the home, in food, in pharmaceutical and industrial production, and in other areas.

3.2.2 Justifies the need to dilute a solution, using examples.

3.2.3 Predicts the concentration of a solute, after diluting a given volume of a solution of a specific concentration.

3.2.4 Justifies his/her prediction.

3.2.5 Compares his/her explanations with those of the other students.

3.2.6 Prepares a given volume of a solution of a specific concentration by diluting a solution of known concentration.

3.2.7 Compares his/her solution with the standard solution.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

* 3.3 Associate the concept of the mole with a measurement of a quantity of matter.

PREREQUISITES:

Module 1-3.4, 4.3, 6.1

RELATED CONTENT:

- SKILL:	Generalizing. (D-6)
- KNOWLEDGE:	Mole, symbol for a mole. Mass, volume, and their units. (A-3)
- ATTITUDE:	Willingness to synthesize and apply knowledge. (I-1)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Brainstorming, presentation, demonstration, class discussion, group work.

B. DURATION:	50 minutes.
C. EVALUATION:	Student's understanding of the concept of the mole.
D. MATERIALS:	A solid, a liquid, a gas. One mole of each of the following substances provided in containers of equal volume (100 mL beakers): NaCl, water, sulphur, mercury, sugar, copper... A balloon blown up to a volume of roughly 25 L.
E. SAFETY MEASURES:	None.

SUGGESTED REFERENCES:

*Video: **CONCEPTS IN SCIENCE SERIES**, TV Ontario, Tape 6, - **The Mole Concept**, a series of six 10-minute programs: 1. **Relative Mass; 2. Gas Volumes; 3. Combining Gas Volumes; 4. Avogadro's Hypothesis; 5. Relative Atomic Mass; 6. The Mole.**

LEARNING ACTIVITIES

THE STUDENT:

3.3.0 Recalls the various phases of matter. (Physical Sciences 214, module on heat and thermal effects).

Recalls Dalton's model (Module 1-4.3).

3.3.1 Lists methods of measuring the quantity of a substance.

3.3.2 Identifies the units of measure and the symbols associated with each method listed in 3.3.1.

3.3.3 Proposes a method of measuring the quantity of a substance involved in a chemical change, based on the atomic model of matter.

3.3.4 Compares his/her proposal with those of the other students.

3.3.5 Becomes aware of the unit used to measure a quantity of atoms and molecules and of the conventional symbol for this unit.

3.3.6 Compares the mass and the volume occupied by one mole of various substances, after observing a demonstration.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

** 3.4 Associate the concept of the mole with Avogadro's number.

PREREQUISITES:

3.3

RELATED CONTENT:

- SKILL: Interpreting data. (D-3)
- KNOWLEDGE: Concept of a mole of molecules and a mole of atoms, Avogadro's number. (A-11)
- ATTITUDE: Willingness to interpret information. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Presentation, class discussion, group work, simulation, individual work.
B. DURATION: (100/150) minutes in class + work at home.
C. EVALUATION: Student's methods of calculation.
D. MATERIALS: Calculator (optional).
E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

Educational Software: **Le nombre d'Avogado,** Projet Seraphim, UQTR.

*Video: **CONCEPTS IN SCIENCE SERIES,** TV Ontario, Tape 6 - **The Mole Concept**, a series of six 10-minute programs: 1. **Relative Mass; 2. Gas Volumes; 3. Combining Gas Volumes; 4. Avogadro's Hypothesis; 5. Relative Atomic Mass; 6. The Mole.**

LEARNING ACTIVITIES

THE STUDENT:

3.4.0 Recalls the atomic structure of matter (Module 1-4.9).

Recalls the molecular structure of matter (Module 1-6.1).

3.4.1 Becomes aware of the definition of a mole in terms of a certain number of particles (atoms, molecules...)

3.4.2 Determines the number of moles of each type of element in one mole of molecules of an element or a compound, based on the molecular formula.

3.4.3 Determines the number of atoms of each element in one mole of molecules of an element or a compound, based on the molecular formula.

3.4.4 Determines the number of moles of each element in different molar quantities of a pure substance, based on the molecular formula.

3.4.5 Determines the number of atoms of each element in different molar quantities of a pure substance, based on the molecular formula.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

* 3.5 Associate the concept of the mole with a measure of the molar mass of a substance.

PREREQUISITES:

3.3

RELATED CONTENT:

- SKILL: Interpreting data. (D-3)
- KNOWLEDGE: Molar mass, gram atomic weight, gram molecular weight.
  Relationship between mole and molar mass of an element. (A-2)
- ATTITUDE: Willingness to interpret information. (I-1)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Brainstorming, presentation, group work, simulation, individual work.

B. DURATION: 50 minutes in class + work at home.

C. EVALUATION: Student's methods of calculation.

D. MATERIALS: Periodic table.

E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

*Videos: **CONCEPTS IN SCIENCE SERIES**, TV Ontario, Tape 6 - **The Mole Concept**, a series of six 10-minute programs: 1. **Relative Mass; 2. Gas Volumes; 3. Combining Gas Volumes; 4. Avogadro's Hypothesis; 5. Relative Atomic Mass; 6. The Mole.**

LEARNING ACTIVITIES

THE STUDENT:

3.5.0 Recalls the concept of the atomic mass of an element (Module 1-5.1).

3.5.1 Lists the reasons why it is impossible to count the number of molecules or atoms in one mole of a substance.

3.5.2 Suggests a method of measurement that could be used to determine the number of moles in a substance.

3.5.3 Becomes aware of the definition of "gram atomic weight" and "gram molecular weight."

3.5.4 Determines the gram atomic weight of given elements, using the periodic table.

3.5.5 Determines the gram molecular weight of given elements and compounds, based on their molecular formulas.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

* 3-6 Prepare an aqueous solution of a given molar concentration, using the dilution procedure.

PREREQUISITES:

3-1, 3-2, 3-5

RELATED CONTENT:

- SKILL: Measuring. (G-1)
- KNOWLEDGE: Molar concentration, c = n/V. (A-7)
- ATTITUDE: Conscientiousness. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Brainstorming, group work, laboratory work.
B. DURATION: 50 minutes.
C. EVALUATION: Student's solutions.
D. MATERIALS: Distilled or demineralized water, coloured solute, stopper, graduated cylinder or pipette, standard solutions, balance (+/- 0.01 g), weighing boat, labels, container of the same volume as those used for standard solutions.
E. SAFETY MEASURES: Glassware, chemicals, measures to protect the environment.

SUGGESTED REFERENCES:

DONOVAN, T.; POOLE, W. and TACK, D. **Chemicals in Action.** Toronto: Holt, Rinehart and Winston of Canada Limited, 1987, pp. 253-254.

LEARNING ACTIVITIES

THE STUDENT:

3.6.1 Proposes a unit of measure for the concentration of a solution.

3.6.2 Compares his/her unit with the conventional unit.

3.6.3 Develops a procedure for preparing a specific volume of a solution of a given molar concentration.

3.6.4 Compares his/her solution with the standard solution.

3.6.5 Dilutes a certain volume of his/her solution to a specific molar concentration.

3.6.6 Compares his/her diluted solution with the standard solution.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and intermediate)

THE STUDENT WILL BE ABLE TO:

* 3.7 State the law regarding the concentration of a solution that contains a constant quantity of solute.

PREREQUISITES:

3.6

RELATED CONTENT:

- SKILL: Generalizing. (G-2)
- KNOWLEDGE: Mathematical relationships $c_1V_1 = c_2V_2$ ... (A-8)
- ATTITUDE: Willingness to interpret information. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Group work, class discussion.
B. DURATION: 50 minutes.
C. EVALUATION: Student's knowledge of the law regarding the concentration of a solution.
D. MATERIALS: Solutions and materials used in 3.6.
E. SAFETY MEASURES: Glassware, recovering solutes.

SUGGESTED REFERENCES:

Educational Software:
- **Solutions/Acides-Bases**, Projet Seraphin, S.G.-T.R.
- **Chemistry: Solutions**, ComPress, Wentworth, NH 03282.

LEARNING ACTIVITIES

THE STUDENT:

3.7.1 Calculates the number of moles of solute used, based on the concentrations and volumes of the solutions prepared in 3.6.

3.7.2 Proposes a mathematical relationship representing the law regarding the concentration of a solution that contains a constant quantity of solute.

3.7.3 Verifies his/her proposal by carrying out another dilution.

3.7.4 Justifies his/her proposal, using unit analysis.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

* 3.8 Solve numerical problems related to the physical quantities associated with a solution.

PREREQUISITES:

3.3, 3.5, 3.6, 3.7

RELATED CONTENT:

- SKILL: Interpreting data. (D-3)
- KNOWLEDGE: Applications of the law concerning the concentration of a solution. (A-7)
- ATTITUDE: Conscientiousness. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Group work, individual work.
B. DURATION: 75 minutes in class + work at home.
C. EVALUATION: Student's methods of calculation.
D. MATERIALS: Calculator (optional).
E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

Educational Software:
- **Solutions/Acides-Bases**, Projet Seraphin, U.Q.T.R.
- **Chemistry: Solutions**, ComPress, Wentworth, NH 03282.

LEARNING ACTIVITIES

THE STUDENT:

3.8.1 Identifies the information needed to solve a problem.

3.8.2 Identifies the appropriate unit of measurement for the physical quantities used in each problem.

3.8.3 Uses mathematical operators correctly when solving the problem.

3.8.4 Verifies that the answer is plausible, using unit analysis.

3.8.5 Verifies that the answer is plausible by calculating the order of magnitude.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

4. **Determine the acidity and the alkalinity of a solution, based on the properties of certain indicators and using the pH scale.**

   4.1 Describe how acids and bases in solution affect certain colour indicators.

PREREQUISITES:

2.1

RELATED CONTENT:

- SKILL:	Observing. (B-2)
- KNOWLEDGE:	How acids and bases affect indicators. (A-1)
- ATTITUDE:	Objectivity. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY: Group work, laboratory work (based on Dalton's theory), class discussion.
B. DURATION: (30/50) minutes.
C. EVALUATION: Student's data table.
D. MATERIALS: Dropper bottles containing 0.1 mol/L HCl and NaOH solutions, dropper bottles containing the following indicators: litmus, methyl orange, phenolphthalein, methyl red, test tubes or depression plates.
E. SAFETY MEASURES: Acids, bases, glassware, measures to protect the environment.

SUGGESTED REFERENCES:

"Acid-Base Magic Wand." **Chem 13 News.** Dept. of Chemistry, University of Waterloo, Dec. 1989, pp. 12-13. (Demo).

GORDON, W. "Chemistry Magic." **Idea Bank Collation.** #334, Vol. 1. Queen's University, Kingston, Ont., (Demo).

Film Loop: **Acid Base Indicators**, 4 min., Ward's Natural Science Establishment.

LEARNING ACTIVITIES

THE STUDENT:

4.1.0 Recalls how litmus is used as an indicator (Module I-2).

4.1.1 Predicts the colour of different indicators in acidic and basic solutions.

4.1.2 Justifies his/her predictions.

4.1.3 Verifies his/her predictions by following the suggested experimental procedure.

4.1.4 Writes down his/her observations in a data table he/she has devised.

4.1.5 Draws conclusions based on his/her analysis of the results.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and intermediate)

THE STUDENT WILL BE ABLE TO:

4.2 Determine the pH of a solution, using a universal indicator.

PREREQUISITES:

4.1

RELATED CONTENT:

- SKILL:	Measuring. (B-5)
- KNOWLEDGE:	Use of a universal indicator, pH, pH scale, intervals on the pH scale associated with acidic and basic solutions. (A-4)
- ATTITUDE:	Objectivity. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Brainstorming, class discussion, laboratory work, group work, individual work.

B. DURATION:	150/75) minutes in class + work at home.
C. EVALUATION:	Results of the student's experiment.
D. MATERIALS:	Buffer solutions (pH 2 to pH 12), solutions that the students bring to class (bleach, vinegar, Windex, Aspirin, wine...), universal indicator solution or indicator paper, small test tubes or depression plates, droppers, labels.
E. SAFETY MEASURES:	Glassware, acidic and basic solutions, measures to protect the environment.

SUGGESTED REFERENCES:

PERKINS, DR. R. "Foaming Colors. **Idea Bank Collation.** #305, Vol. I. Queen's University, Kingston, Ont.
SHAPIRO, B. and SHAPIRO, S. **Chemistry at Work.** Mississauga, Ont.: Copp Clark Pitman Ltd., 1985, pp. 202-207.

LEARNING ACTIVITIES

THE STUDENT:

4.2.1 Lists situations from everyday life in which the term pH is used.

4.2.2 Proposes a definition for the term pH.

4.2.3 Compares his/her proposal with those of other students.

4.2.4 Determines the colour of a universal indicator in various solutions by conducting an experiment.

4.2.5 Associates each colour obtained with a position on the pH scale.

4.2.6 Associates the pH value with the acidity or the alkalinity of a solution.

4.2.7 Determines the pH of common consumer goods.

4.2.8 Determines the pH of various parts of the human body.

4.2.9 Writes a report on the experiment he/she has conducted.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

4.3 Determine the turning point of an indicator.

PREREQUISITES:

4.2

RELATED CONTENT:

- SKILL: Interpreting data. (D-5)
- KNOWLEDGE: Concept of the turning point of an indicator. (A-1)
- ATTITUDE: Creative approach. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Group work, laboratory work, class discussion.
B. DURATION: (50/75) minutes.
C. EVALUATION: Student's ability to interpret data.
D. MATERIALS: Buffer solutions (pH 2 to pH 12), indicators used in 4.1, small test tubes or depression plates, and pH meter in the preparation room (+/- 0.1).
E. [illegible] EASURES: Glassware, acidic and basic solutions, measures to protect the environment.

[illegible] FERENCES:

[illegible] nd SHAPIRO, S. **Chemistry at Work.**
[illegible] e, Ont.: Copp Clark Pitman Ltd., 1989,
[illegible] 09.
[illegible] **Base Indicators**, 19 min, Ward's Natural
[illegible] ce Establishment.

LEARNING ACTIVITIES

THE STUDENT:

4.3.1 Predicts the colour of the indicators used in 4.1 when they are added to acidic and basic solutions of various concentrations.

4.3.2 Justifies his/her predictions.

4.3.3 Develops an experimental procedure to verify these predictions.

4.3.4 Records his/her observations in a data table.

4.3.5 Associates the turning point with the pH of a solution.

4.3.6 Suggests everyday and scientific uses for colour indicators.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

4.4 Determine the turning points of a mixture of two indicators.

PREREQUISITES:

4.3

RELATED CONTENT:

- SKILL: Interpreting data. (D-5)
- KNOWLEDGE: Concept of the turning points of a mixture of indicators. (A-1)
- ATTITUDE: Conscientiousness. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Group work, laboratory work, class discussion, individual work.

B. DURATION: (75/100) minutes in class + work at home.

C. EVALUATION: Student's report on the experiment.

D. MATERIALS: Same as 4.2.

E. SAFETY MEASURES: Glassware, acidic and basic solutions, measures to protect the environment.

SUGGESTED REFERENCES:

Handbook of Chemistry, McGraw-Hill Book Company.

LEARNING ACTIVITIES

THE STUDENT:

4.4.1 Predicts the turning points and the colours of a mixture of two indicators when it is added to the acidic and basic solutions used in 4.2.

4.4.2 Justifies his/her predictions.

4.4.3 Develops an experimental procedure to verify his/her predictions.

4.4.4 Compares his/her results with his/her predictions.

4.4.5 Explains any differences between the predictions and the results.

4.4.6 Associates the turning points of a mixture of indicators with the solutions used in 4.2.

4.4.7 Writes a report on the experiment he/she has conducted.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and intermediate)

THE STUDENT WILL BE ABLE TO:

4.5 Identify coloured household substances that can be used as indicators, after conducting experiments.

PREREQUISITES:

4.3

RELATED CONTENT:

- SKILL: Interpreting data. (D-6)
- KNOWLEDGE: Turning points of substances used in the home. (K-10)
- ATTITUDE: Fascination with science. (W-5)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Brainstorming, group work, laboratory work, class discussion, individual work.

B. DURATION: (75/100) minutes in class + work at home.

C. EVALUATION: Student's report on the research and the experiment.

D. MATERIALS: Buffer solutions used in 4.2, solution of the substance that the student brings to class (grape juice, beet juice, red cabbage juice, mustard...), small test tubes or depression plates, table to compile the class's results, reference materials, source of heat, colour chart.

E. SAFETY MEASURES: Glassware, acidic and basic solutions, source of heat, measures to protect the environment.

SUGGESTED REFERENCES:

DONOVAN, T.; POOLE, M. and YACK, D. **Chemicals in Action.** Toronto: Holt, Rinehart and Winston of Canada Limited, 1987, pp. 248-249.
SHAPIRO, R. and SHAPIRO, S. **Chemistry at Work.** Mississauga, Ont.: Copp Clark Pitman LTD., 1989, pp. 196-197.

LEARNING ACTIVITIES

THE STUDENT:

4.5.1 Suggests coloured household substances that could be used as indicators.

4.5.2 Develops an experimental procedure to determine the turning point of one of the proposed substances.

4.5.3 Presents his/her results in a data table used to compile the class's results.

4.5.4 Demonstrates Robert Boyle's contribution to the study of indicators.

4.5.5 Writes a report on his/her experiment and research.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

* 4.5 Associate the pH scale with the scale of the molar concentrations of H+ and OH- ions.

PREREQUISITES:

3.6 and 4.2

RELATED CONTENT:

-	SKILL:	Interpreting data. (D-2)
-	KNOWLEDGE:	Relationship between pH and molar concentration, concept of chemical neutrality, intervals on the pH scale that indicate acidity and alkalinity. (A-11)
-	ATTITUDE:	Willingness to interpret information. (M-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Presentation, group work, simulation, class discussion, individual work.

B. DURATION: 50 minutes in class + work at home.

C. EVALUATION: Student's understanding of the concept of pH.

D. MATERIALS: Table of indicator colours, reference materials.

E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

DORIN, H. **Chemistry: The Study of Matter.** Fairfield, N.J.: Cebco Standard Publishing, 1982, pp. 470-471.

Le petit Robert 2, Dictionnaire universel des noms propres.

LEARNING ACTIVITIES

THE STUDENT:

4.5.1 Ascertains that there is no unit of measure for the pH of a solution.

4.5.2 Associates the pH of a solution with the value of the concentration of H+ and OH- ions.

4.5.3 Associates an increase in the pH value with a decrease in the concentration of H+ ions.

4.5.4 Associates an increase in the pH value with an increase in the concentration of OH- ions.

4.5.5 Explains the origin of the term "Sorensen index."

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

* 4.7 Explain the molar concentration of H+ and OH- ions in pure water, based on its pH value and molecular formula.

PREREQUISITES:

4.6

RELATED CONTENT:

- SKILL: Interpreting data. (D-3)
- KNOWLEDGE: Explanation for the chemical neutrality of pure water, conditions associated with neutralization, pH of pure water, pH of a neutral aqueous solution, molecular formula of water (HOH). (A-1)
- ATTITUDE: Willingness to synthesize and apply knowledge. (F-1)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Laboratory work, presentation, class discussion.
B. DURATION: 50 minutes.
C. EVALUATION: Student's understanding of the theory of neutralization.
D. MATERIALS: Solution with a pH of 7, pH paper.
E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

LEARNING ACTIVITIES

THE STUDENT:

4.7.1 Measures the molar concentration of H+ ions in pure water, using pH paper.

4.7.2 Formulates a hypothesis regarding the molar concentration of OH- ions in pure water, based on his/her measure and the molecular formula.

4.7.3 Associates the neutrality of a solution with equal concentrations of H+ and OH- ions.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

** 4.5 Identify ways of improving the measure of the pH of a solution.

PREREQUISITES:

4.2

RELATED CONTENT:

- SKILL: Measuring. (B-5)
- KNOWLEDGE: Method of measuring pH. (A-7)
- ATTITUDE: Critical attitude. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Laboratory work, class discussion, brainstorming.

B. DURATION: (50/75) minutes.

C. EVALUATION: Student's suggestions for improving pH measures.

D. MATERIALS: Strips of pH paper covering various ranges, dropper bottles, tap water, pH meter (optional).

E. SAFETY MEASURES: Precautions in handling lab materials.

SUGGESTED REFERENCES:

SHAPIRO, B. and SHAPIRO, S. **Chemistry at Work.** Mississauga, Ont.: Copp Clark Pitman Ltd., 1989, pp. 212-214.

LEARNING ACTIVITIES

THE STUDENT:

4.5.1 Measures the pH of an acidic solution, using pH paper.

4.5.2 Compares his/her measures with those of the other students.

4.5.3 Determines the differences between various measures of the pH of an acidic solution.

4.5.4 Proposes ways of improving measuring techniques in order to minimize these differences.

4.5.5 Verifies the methods he/she has proposed, by conducting an experiment.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and intermediate)

THE STUDENT WILL BE ABLE TO:

5. **Analyze chemical changes, based on the law of conservation of matter with which he/she has become familiar while doing laboratory experiments.**

   5.1 Neutralize an acidic or basic substance in his/her environment.

PREREQUISITES:

4.2

RELATED CONTENT:

- SKILL:	Developing an experimental procedure. (C-4)
- KNOWLEDGE:	Neutralization of acids and bases; equivalence point. (A-1)
- ATTITUDE:	Willingness to clarify problems. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Brainstorming, group work, laboratory work, class discussion.
B. DURATION: (75/125) minutes.
C. EVALUATION: Student's report on the experiment.
D. MATERIALS: Depending on the experimental procedure.
E. SAFETY MEASURES: Toxicity of the products involved in the reactions. Glassware, acidic and basic solutions, measures to protect the environment.

SUGGESTED REFERENCES:

SHAPIRO, B. and SHAPIRO, S. **Chemistry at Work.** Mississauga, Ont.: Copp Clark Pitman Ltd., 1989, p. 232, "Concentration of Ammonia in Household Cleaners;" p. 233, "Concentration of Acetic Acid in Vinegar."

LEARNING ACTIVITIES

THE STUDENT:

5.1.1 Suggests a method of neutralizing a substance that he/she has chosen from his/her environment.

5.1.2 Develops an experimental procedure to verify his/her proposal.

5.1.3 Carries out the experiment.

5.1.4 Writes a report on the experiment he/she has conducted.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

5.2 Represent a chemical change, after conducting an experiment involving a neutralization reaction.

PREREQUISITES:

2.1, 2.2

RELATED CONTENT:

- SKILL:	Generalizing. (F-1)
- KNOWLEDGE:	Representation of a chemical change, use of a carbonate to neutralize an acid. (A-4)
- ATTITUDE:	Concern for the use of correct language. (F-4)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Group work, laboratory work, class discussion.

B. DURATION:	(100/150) minutes.
C. EVALUATION:	Student's representation of a chemical change.
D. MATERIALS:	Tests tubes, HCl solution (1 mol/L), $CaCO_3$, methyl orange solution, matches, one-hole stopper, bent glass tubes, rubber tubing, limewater solution, wooden splints.
E. SAFETY MEASURES:	Glassware, acidic solution, flame.

SUGGESTED REFERENCES:

SHAPIRO, B. and SHAPIRO, S. **Chemistry at Work.** Mississauga, Ont.: Copp Clark Pitman Ltd., 1989, pp. 226-231.

LEARNING ACTIVITIES

THE STUDENT:

5.2.0 Recalls method for identifying limestone (Physical Science 214).

Recalls the characteristics of chemical changes (Module 1-3.3, 3.4).

Recalls the concept of the molecular formula of a substance (Module 1-6.4).

5.2.1 Suggests ways of neutralizing an acidic solution.

5.2.2 Suggests a name and a formula for the gas likely to be formed when an acid is neutralized by a carbonate, based on the names and the formulas of the substances in question.

5.2.3 Develops a procedure to test his/her hypothesis.

5.2.4 Indicates the name and the formula of the gas produced during the neutralization process, based on a characteristic property of that gas.

5.2.5 Proposes a representation for the chemical change he/she has brought about.

5.2.6 Compares his/her proposal with those of other students.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

5.3 Explain the law of conservation of matter in a a chemical change, after conducting an experiment involving a neutralization reaction.

PREREQUISITES:

2.1, 5.1

RELATED CONTENT:

- SKILL: Generalizing. (D-6)
- KNOWLEDGE: Law of conservation of mass. (A-8)
- ATTITUDE: Conscientious. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Brainstorming, group work, laboratory work, simulation, class discussion.
B. DURATION: (100/150) minutes.
C. EVALUATION: Student's measurement techniques.
D. MATERIALS: Balance (+/- 0.01 g), 100 mL beaker, equal volumes of acids and bases (0.1 mol/L), litmus solution in dropper bottles, 10 mL or 50 mL graduated cylinder.
E. SAFETY MEASURES: Glassware, acidic and basic solutions, measures to protect the environment.

SUGGESTED REFERENCES:

*Video: **ABOUT SCIENCE SERIES**, TV Ontario, Tape 4, 25 min.

LEARNING ACTIVITIES

THE STUDENT:

5.3.1 Formulates a hypothesis regarding the conservation of mass of substances involved when an acid is neutralized by a base.

5.3.2 Justifies his/her hypothesis.

5.3.3 Develops an experimental procedure to test his/her hypothesis.

5.3.4 Formulates a law of conservation of mass during a neutralization, based on the experimental data obtained.

5.3.5 Compares his/her law with those of other students.

5.3.6 Refers to other chemical changes in order to formulate a general law.

5.3.7 Compares his/her law with the one formulated by Antoine Laurent Lavoisier in the eighteenth century.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

5.4 Represent chemical changes in the form of balanced equations.

PREREQUISITES:

5.2

RELATED CONTENT:

- SKILL: Constructing a model. (E-6)
- KNOWLEDGE: Acid + base → salt + water, concept of a balanced equation: each side of the equation has the same number of atoms of each element. Trial-and-error method for balancing equations. (A-4)
- ATTITUDE: Willingness to synthesize and apply knowledge. (F-4)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Demonstration, individual work, simulation, class discussion.

B. DURATION: (50/100) minutes in class + work at home.

C. EVALUATION: Method used by students to balance equations.

D. MATERIALS: Equal volumes of NaOH and HCl solutions (1.0 mol/L), 100 mL beaker, burner or heating plate, ring stand, ring, wire gauze.

E. SAFETY MEASURES: Glassware, acidic and basic solutions, measures to protect the environment.

SUGGESTED REFERENCES:

Educational Software: **Chemistry: Chemical Formulas and Equations**, Compress, Wentworth, NH 03282.

LEARNING ACTIVITIES

THE STUDENT:

5.4.0 Recalls ways of predicting which elements make up a compound (Module 1-3.3, 3.4).

5.4.1 Becomes aware of the nature of the substances produced when an acid is neutralized by a base, after observing a demonstration.

5.4.2 Represents the neutralization of an acid by a base in the form of a chemical equation.

5.4.3 Compares the number of atoms of each element before the chemical change with the number of atoms present after the chemical change by examining the equation.

5.4.4 Draws a conclusion based on the results of that comparison.

5.4.5 Discusses his/her conclusion.

5.4.6 Balances various chemical equations, based on the number of atoms of each element.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and intermediate)

THE STUDENT WILL BE ABLE TO:

- 5.5 Verify that various chemical changes are consistent with the law of conservation of mass.

PREREQUISITES:

3.4, 5.2, 5.4

RELATED CONTENT:

- SKILL: Generalizing. (F-1)
- KNOWLEDGE: Application of Lavoisier's law of conservation of mass. (A-8)
- ATTITUDE: Conscientiousness. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Group work, individual work.
B. DURATION: 60 minutes + work at home.
C. EVALUATION: Student's methods of calculation.
D. MATERIALS: None.
E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

*Video: **ABOUT SCIENCE SERIES**, TV Ontario, Tape 4, one 5-minute program:
14. Conversion of Matter.

LEARNING ACTIVITIES

THE STUDENT:

5.5.1 Writes a balanced chemical equation for the neutralization reaction carried out in 5.2.

5.5.2 Determines the molar mass of each substance.

5.5.3 Verifies that the chemical equation is consistent with the law of conservation of mass by checking the molar masses of each substance.

5.5.4 Makes a generalization about the applicatio of the law of conservation of mass to oth chemical changes.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and intermediate)

THE STUDENT WILL BE ABLE TO:

- 5.6 Determine the quantity of a substance involved in a chemical reaction, using stoichiometric calculations.

PREREQUISITES:

5.5

RELATED CONTENT:

- SKILL: Formulating hypotheses. (C-2)
- KNOWLEDGE: Stoichiometry. (A-8)
- ATTITUDE: Critical attitude. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Group work, laboratory work, class discussion.
B. DURATION: 60 minutes.
C. EVALUATION: Student's laboratory work.
D. MATERIALS: Balance, beaker, graduated cylinder, funnel, filter paper, filtering flask, Na_2CO_3 and $CaCl_2$ solutions of equal volume and concentration (10 mL at 1 mol/L) (dessicated reactants).
E. SAFETY MEASURES: Glassware.

SUGGESTED REFERENCES:

SHAPIRO, B. and SHAPIRO, S. **Chemistry at Work.** Mississauga, Ont.: Copp Clark Pitman Ltd., 1989, pp. 174-177.

LEARNING ACTIVITIES

THE STUDENT:

5.6.0 Recalls the concept of a mole (3.2).

Recalls the concept of the molar concentration of a solution (3.4).

5.6.1 Predicts the number of moles and the number of molecules produced during a chemical change, based on a balanced chemical equation.

5.6.2 Compares his/her predictions with those of the other students.

5.6.3 Modifies his/her prediction, if necessary.

5.6.4 Predicts the amount of precipitate produced during a chemical change, based on the volume and concentration of two substances in solution.

5.6.5 Tests his/her hypothesis by conducting an experiment.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

** 5.7 Describe how the discovery of the law of conservation of matter contributed to the development of scientific knowledge, after consulting reference materials.

PREREQUISITES:

5.3

RELATED CONTENT:

- SKILL: Generalizing. (F-1)
- KNOWLEDGE: Impact of the discovery of the law of conservation of matter. Modification of scientific theories in light of scientific discoveries ($E = mc^2$). (A-1)
- ATTITUDE: "Constructivist" view of science. (I-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Individual work, group work, class discussion.
B. DURATION: (40/50) minutes in class + work at home.
C. EVALUATION: Research paper.
D. MATERIALS: Reference materials.
E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

LAVOISIER, Antoine Laurent. **Extraits de traité élémentaire de chimie présentés par Henri Montias**, Paris, Gauthier-Villars Éditeur, 1964, 64 p., (collection au savant dans le texte).

Le Petit Robert 2, Dictionnaire universel des noms propres.

LEARNING ACTIVITIES

THE STUDENT:

5.7.1 Describes how Antoine Laurent Lavoisier discovered the law of conservation of mass.

5.7.2 Shows how Lavoisier's work influenced the experimental approach used by chemists at that time.

5.7.3 Shows how the discovery of the law of conservation of matter led to the discovery of other laws.

5.7.4 States the laws that follow from the law of conservation of matter.

5.7.5 Becomes aware of the limitations of the law of conservation of mass in light of Einstein's mass-energy equivalence relationship.

5.7.6 Describes Lavoisier's other scientific work.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

- 5.8 Solve numerical problems related to stoichiometry.

PREREQUISITES:

5.6

RELATED CONTENT:

- SKILL: Interpreting data. (D-1)
- KNOWLEDGE: Stoichiometric calculations. (A-7)
- ATTITUDE: Conscientiousness. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Group work, individual work.
B. DURATION: 75 minutes in class + work at home.
C. EVALUATION: Student's methods of calculation.
D. MATERIALS: None.
E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

LEDBETTER, E. and YOUNG, J. **Keys to Chemistry.** Addison Wesley Publishing, 1977, pp. 215-216.

LEARNING ACTIVITIES

THE STUDENT:

5.8.1 Identifies the information needed to solve a problem.

5.8.2 Identifies the appropriate unit of measurement for the physical quantities used in each problem.

5.8.3 Uses mathematical operators correctly when solving numerical problems.

5.8.4 Verifies that the answer is plausible, using unit analysis.

5.8.5 Verifies that the answer is plausible by calculating the order of magnitude.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and intermediate)

THE STUDENT WILL BE ABLE TO:

* 5.8 Solve numerical problems related to stoichiometry.

PREREQUISITES:

5.6

RELATED CONTENT:

- SKILL: Interpreting data. (D-1)
- KNOWLEDGE: Stoichiometric calculations. (A-7)
- ATTITUDE: Conscientiousness. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Group work, individual work.
B. DURATION: 75 minutes in class + work at home.
C. EVALUATION: Student's methods of calculation.
D. MATERIALS: None.
E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

LEDBETTER, E. and YOUNG, J. **Keys to Chemistry.** Addison Wesley Publishing, 1977, pp. 215-216.

LEARNING ACTIVITIES

THE STUDENT:

5.8.1 Identifies the information needed to solve a problem.

5.8.2 Identifies the appropriate unit of measurement for the physical quantities used in each problem.

5.8.3 Uses mathematical operators correctly when solving numerical problems.

5.8.4 Verifies that the answer is plausible, using unit analysis.

5.8.5 Verifies that the answer is plausible by calculating the order of magnitude.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

6. **Make an environmental impact study of the use of matter.**

   6.1 Explain the formation of acid precipitation after conducting an experiment.

PREREQUISITES:

2.1, 4.2

RELATED CONTENT:

- SKILL:	Formulating a hypothesis. (C-2)
- KNOWLEDGE:	Combustion, acidic or basic property of oxides, sources of acid precipitation, circulation of acid pollutants. (A-1)
- ATTITUDE:	Willingness to compare ideas. (M-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Brainstorming, group work, laboratory work, simulation, individual work, class discussion.

B. DURATION: (100/150) minutes in class + work at home.

C. EVALUATION: Quality of the explanation.

D. MATERIALS: Mg, matches, distilled water (pH 7), test tubes, erlenmeyer flasks, beakers, glass tubing, rubber tubing, tongs, stoppers, burner, litmus paper, map of North America, reference materials, source of CO_2 and SO_2.

E. SAFETY MEASURES: Glassware, heating, chemical substances, measures to protect the environment.

SUGGESTED REFERENCES:

ANDREWS, William A. **Guide to the Study of Environmental Pollution.** Scarborough, Ont.: Prentice-Hall, 1972.

CARPENTIER, Jean-Marc. **Our Energy Heritage.** Montreal: Meridian Press, 1989, p. 216, SOQUIP, section on oil and gas.

Brochures:
- Quebec, Ministère de l'Environnement. **Les précipitations acides et l'environnement.** Quebec: ministère de l'Environnement, 24 pages.
- Quebec. Ministère de l'Environnement. **Quand la pluie chasse les grenouilles.** Quebec: ministère de l'Environnement, 29 pages.

LEARNING ACTIVITIES

THE STUDENT:

6.1.0 Recalls the water cycle (Ecology 114).

Recalls the composition of air (Physical Sciences 214, module on meteorology).

Recalls the circulation of gases in the atmosphere (Physical Sciences 214, module on meteorology).

Recalls the phases of matter (Physical Sciences 214, module on heat and thermal effects).

Recalls the classification of metals and non-metals (Module 1-5.4).

Recalls the concept of the molecular formula of a substance (Module 1-6.4).

6.1.1 Suggests an explanation for the formation of acid precipitation, based on the knowledge he/she has acquired through school work, readings, and the media.

6.1.2 Determines the pH of an aqueous solution of the product that results from the combustion of a non-metal.

6.1.3 Determines the pH of an aqueous solution of the product that results from the combustion of a metal.

6.1.4 Relates these observations to natural phenomena.

6.1.5 Illustrates the formation of acid precipitation by referring to the water cycle.

6.1.6 Suggests a reason why basic precipitation does not exist.

6.1.7 Compares his/her explanation with those of the other students.

6.1.8 Indicates, on a map of North America, the main sources and the paths of pollutants responsible for the formation of acid precipitation in Québec, after consulting reference materials.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

** 6.2 Identify the effects of acid precipitation on the environment.

PREREQUISITES:

4.5, 6.1

RELATED CONTENT:

- SKILL: Observing. (B-1)
- KNOWLEDGE: Environmental effects of acid precipitation. (A-1)
- ATTITUDE: Objectivity. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Field trips, laboratory work, individual work, interview, class discussion.
B. DURATION: (90/100) minutes in class + work at home.
C. EVALUATION: Student's observations.
D. MATERIALS: Reference materials, pH paper, pluviometer, commonly used substances (e.g., juice, vinegar).
E. SAFETY MEASURES: Glassware, chemicals.

SUGGESTED REFERENCES:

Videos:
- **Acid Rain**, 30 min, TV Ontario.
- **Acid Rain from Heaven**, 30 min 47 sec, 1981, N.F.B.
- **Air**, 2 min 30 sec, 1972, N.F.B.
- **La pollution venue du ciel**, 74 min, N.F.B., 1984, 3 documents: "S.P.L.A.S.H.", "Les pluies acides: à la croisée des chemins", "Une pluie acide du ciel".

LEARNING ACTIVITIES

THE STUDENT:

6.2.1 Compares the pH of precipitation with the pH of commonly used substances, after measuring the acidity of each.

6.2.2 Lists the effects of acid precipitation on the environment, after consulting reference materials.

6.2.3 Identifies the possible effects of acid precipitation on the physical and biological environment in his/her region.

6.2.4 Assesses the magnitude of the problem in his/her region.

6.2.5 Discusses his/her assessment.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

** 6.3 Describe ways of diminishing the effects of acid precipitation on the environment.

PREREQUISITES:

5.1, 6.2

RELATED CONTENT:

- SKILL: Formulating hypotheses. (C-2)
- KNOWLEDGE: Ways of diminishing the effects of acid precipitation. (A-1)
- ATTITUDE: Critical attitude. [illegible]-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Brainstorming, group work, laboratory work, interview, individual work, class discussion.
B. DURATION: (50/75) minutes.
C. EVALUATION: Quality of the student's discussion.
D. MATERIALS: Reference materials related to the student's proposal.
E. SAFETY MEASURES: Depending on the experiments conducted.

SUGGESTED REFERENCES:

The Canadian Green Consumer Guide: How Can We Help? Toronto: McClelland and Stewart Inc., 1989, pp. 16-26, Chapter 1, "Costing the Earth."

Video: **Acid Rain: Requiem or Recovery**, 28 min 50 sec, N.F.B., 1986.

LEARNING ACTIVITIES

THE STUDENT:

6.3.1 Suggests ways of diminishing the effects of acid precipitation on the physical and biological environment.

6.3.2 Compares his/her proposal with those of the other students.

6.3.3 Verifies one of his/her proposals by conducting an experiment.

6.3.4 Discusses the responsibility of industry, individuals, and government organizations with regard to diminishing the effects of acid precipitation on the environment.

6.3.5 Assesses the effectiveness of the methods proposed by industry, individuals, and governments to diminish the environmental effects of acid precipitation, after consulting reference materials.

6.3.6 Comments on conflicting views regarding the possible effects of acid precipitation by examining the media's coverage of this problem.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and intermediate)

THE STUDENT WILL BE ABLE TO:

6.4 Identify the effects of chemical substances released into the environment.

PREREQUISITES:

RELATED CONTENT:

- SKILL: Recognizing a problem. (C-1)
- KNOWLEDGE: Environmental impact of the use of chemical substances. (A-1)
- ATTITUDE: Sense of responsibility (concern for the environment). (I-5)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Field trips, group work, individual work, class discussion.
B. DURATION: (50/100) minutes in class + work at home.
C. EVALUATION: Student's argumentation.
D. MATERIALS: References materials, camera and film, videotape camera.
E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

16 mm Film: **Water, Water Everywhere**, 4 min 45 sec, 1971, N.F.B.
Videos: - **A Time for Action**, 10 min, 1983, N.F.B.
- **Paradise Lost**, 3 min 48 sec, 1977, N.F.B.

LEARNING ACTIVITIES

THE STUDENT:

6.4.0 Recalls the concept of a chemical change. (Module 1-3.2).

6.4.1 Identifies chemical substances released into the air, the water, and the soil in his/her environment.

6.4.2 Estimates the annual per capita quantities of chemical substances released into the environment, after consulting reference materials.

6.4.3 Associates some of these substances with their effects on the biotic environment and the abiotic environment.

6.4.4 Illustrates the effects of chemical emissions on his/her environment, using diagrams, photographs and other illustrations.

6.4.5 Describes how chemical emissions have transformed the biotic environment and the abiotic environment, after consulting reference materials.

6.4.6 Communicates his/her findings.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

** 6.5 Assess various methods of reducing the amount of chemical waste released into the environment.

PREREQUISITES:

6.4

RELATED CONTENT:

- SKILL: Generalizing. (B-2)
- KNOWLEDGE: Methods of reducing the amount of chemical waste released into the environment. (A-10)
- ATTITUDE: Objectivity. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Group work, individual work, interview, class discussion.

B. DURATION: (90/75) minutes in class + work at home.

C. EVALUATION: Student's procedure.

D. MATERIALS: Reference materials.

E. SAFETY MEASURES: Safe and hygienic waste management techniques.

SUGGESTED REFERENCES:

DONOVAN, T.; POOLE, M. and YACK, D. **Chemicals in Action.** Toronto: Holt, Rinehart and Winston of Canada Limited, 1987, pp. 284-292.

ORD, D. **Modern Chemistry.** Hightstown, N.J.: McGraw-Hill Ryerson Ltd., 1986, pp. 294-317.

16 mm Films: **Water**, 14 min 18 sec, 1981, N.F.B.
Man: The Polluter, 53 min 20 sec, 1973, N.F.B.

Video: **A Time for Action**, 10 min, 1983, N.F.B.

LEARNING ACTIVITIES

THE STUDENT:

6.5.1 Suggests a procedure for analyzing the type and estimating the amount of waste he/she produces in a given time frame.

6.5.2 Carries out his/her procedure.

6.5.3 Suggests ways of reducing the amount of chemical waste he/she releases into his/her environment.

6.5.4 Discusses his/her suggestions with other students.

6.5.5 Compares his/her suggestions with methods currently used in society.

6.5.6 Distinguishes between the chemical waste that can be recycled and the chemical waste that cannot be recycled.

6.5.7 Suggests methods that make it easier to recycle chemical substances.

6.5.8 Suggests methods of reducing the quantities of non-recyclable chemical substances.

6.5.9 Compares the methods suggested in 6.5.6 and 6.5.7 with those presently used in his/her community.

6.5.10 Communicates his/her findings.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and intermediate)

THE STUDENT WILL BE ABLE TO:

7. **Make a study of how the development of the chemical industry has affected Québec society.**

7.1 Describe the importance of the production of chemical substances in Québec, after consulting reference materials.

PREREQUISITES:

Module 1-2

RELATED CONTENT:

- SKILL: Observing. (B-1)
- KNOWLEDGE: Substances produced in Québec, their social, economic and environmental effects. (A-1)
- ATTITUDE: Intellectual curiosity. (H-5)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Individual work, group work, class discussion.
B. DURATION: (75/125) minutes in class + work at home.
C. EVALUATION: Student's research paper.
D. MATERIALS: Reference materials.
E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

The American Chemical Society. **Chemistry in the Community (Chem Comm), The Chemical Industry: Promise and Challenge.** Dubuque, Iowa: Kendall/Hunt Publishing Co., 1988.

LEARNING ACTIVITIES

THE STUDENT:

7.1.1 Lists chemical substances manufactured in Québec.

7.1.2 Indicates which of these substances is produced in his/her region.

7.1.3 Lists the ways in which these chemical substances are used.

7.1.4 Identifies countries that use substances produced in Québec.

7.1.5 Identifies the social, economic, and environmental effects of the production of these substances on his/her region.

7.1.6 Writes a short paper on the importance of the production of chemical substances for Québec society.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

** 7.2 Identify the major steps in the development of a particular branch of Québec's chemical industry.

PREREQUISITES:

7.1

RELATED CONTENT:

- SKILL: Observing. (B-2)
- KNOWLEDGE: History of Québec's chemical industry. (A-1)
- ATTITUDE: Sense of belonging. (H-6)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Group work, individual work, interview, class discussion.
B. DURATION: (75/125) minutes in class + work at home.
C. EVALUATION: Research paper.
D. MATERIALS: Reference materials.
E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

CLICHE, Jean-Marie. "Industrie chinique québécoise," **Spectre**, vol. 18, N° 4, (mars 1989), pp. 9-24.
Video: **Petroleum's Progress**, 6 min 8 sec, 1978, N.F.B.

LEARNING ACTIVITIES

THE STUDENT:

7.2.1 Lists different branches of Québec's chemical industry (e.g. food, metallurgical, pulp and paper, petroleum, pharmaceutical, plastics).

7.2.2 Identifies the resources which made it advantageous to establish a particular branch of the chemical industry in his/her region.

7.2.3 Identifies scientists, industrialists, and politicians who contributed to the development of Québec's chemical industry.

7.2.4 Describes the history of one of those branches of the chemical industry after consulting reference materials.

7.2.5 Writes a short paper on the major steps in the development of the branch of the chemical industry that he/she has chosen.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

** 7.2 Identify the major steps in the development of a particular branch of Québec's chemical industry.

PREREQUISITES:

7.1

RELATED CONTENT:

- SKILL: Observing. (B-2)
- KNOWLEDGE: History of Québec's chemical industry. (A-1)
- ATTITUDE: Sense of belonging. (H-6)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Group work, individual work, interview, class discussion.
B. DURATION: (75/125) minutes in class + work at home.
C. EVALUATION: Research paper.
D. MATERIALS: Reference materials.
E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

CLICHE, Jean-Marie. "Industrie chimique québécoise," **Spectre**, vol. 18, N° 4, (mars 1989), pp. 9-24.
Video: **Petroleum's Progress**, 6 min 8 sec, 1978, N.F.B.

LEARNING ACTIVITIES

THE STUDENT:

7.2.1 Lists different branches of Québec's chemical industry (e.g. food, metallurgical, pulp and paper, petroleum, pharmaceutical, plastics).

7.2.2 Identifies the resources which made it advantageous to establish a particular branch of the chemical industry in his/her region.

7.2.3 Identifies scientists, industrialists, and politicians who contributed to the development of Québec's chemical industry.

7.2.4 Describes the history of one of these branches of the chemical industry after consulting reference materials.

7.2.5 Writes a short paper on the major steps in the development of the branch of the chemical industry that he/she has chosen.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

7.3 Analyze the social, economic, and environmental consequences of consumer product recycling in Québec.

PREREQUISITES:

Module 1-2.4, 7.1

RELATED CONTENT:

- SKILL:	Interpreting data. (D-3)
- KNOWLEDGE:	Effect of recycling consumer goods. (A-1)
- ATTITUDE:	Objectivity. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Brainstorming, individual work, interview, class discussion.

B. DURATION:	(50/75) minutes in class + work at home.
C. EVALUATION:	Student's ability to interpret the data.
D. MATERIALS:	Reference materials.
E. SAFETY MEASURES:	None.

SUGGESTED REFERENCES:

16 mm Film: **A Matter of Attitude**, 29 min, 1968, N.F.B.

Video: **The Underlying Threat**, 48 min, N.F.B.

LEARNING ACTIVITIES

THE STUDENT:

7.3.1 Lists common methods of disposing of consumer goods.

7.3.2 Compares the economic effects of these methods with the effects of recycling consumer goods.

7.3.3 Shows how product recycling and product disposal techniques affect energy and resource conservation.

7.3.4 Describes the effects of consumer product recycling on Québec society.

7.3.5 Identifies companies in his/her region that recycle consumer goods.

7.3.6 Discusses the importance of the properties of the materials used to manufacture consumer goods.

7.3.7 Writes a short paper on the importance of consumer product recycling for Québec society.

TEACHER'S NOTES:

SPECIFIC OBJECTIVES
(Terminal and Intermediate)

THE STUDENT WILL BE ABLE TO:

** 7.4 Evaluate techniques used to dispose of and recycle chemical waste.

PREREQUISITES:

7.3

RELATED CONTENT:

- SKILL: Observing. (B-1)
- KNOWLEDGE: Techniques for disposing of and reprocessing chemical waste. (A-1)
- ATTITUDE: Critical attitude. (H-3)

SUGGESTED TEACHING PLAN:

A. TEACHING STRATEGY:
Field trip, interview, group work, individual work, class discussion.
B. DURATION: (90/75) minutes in class + work at home.
C. EVALUATION: Student's ability to analyze the topic critically.
D. MATERIALS: Reference materials.
E. SAFETY MEASURES: None.

SUGGESTED REFERENCES:

"Special Environment - les efforts de dépollution," **Québec Science**, vol. 27, N° 9, (mai 1989).
Video: **PERSPECTIVES IN SCIENCE SERIES: Toxic Waste Water**, 60 min, 1989, N.F.B.

LEARNING ACTIVITIES

THE STUDENT:

7.4.1 Compares the quantity of chemicals produced in Québec with the amount of treated chemical waste.

7.4.2 Observes techniques used to dispose of or recycle chemical waste, while visiting an industrial work place or a recycling plant in his/her region.

7.4.3 Becomes familiar with other modern techniques used to dispose of or recycle chemical waste.

7.4.4 Discusses the responsibility of industry and individuals with regard to ensuring that environmental concerns govern the choice of raw materials used to manufacture consumer goods.

7.4.5 Describes examples of non-polluting chemicals that could be substituted for polluting chemicals.

7.4.6 Writes a report on the current situation regarding the disposal and recycling of chemical waste.

TEACHER'S NOTES:

6. EVALUATION

A program would be incomplete if it did not include methods of evaluation. Evaluation is an integral part of learning and teaching. While its main goal is to improve the quality of the decisions regarding the education and general development of students, it is first and foremost a way of determining whether students have assimilated the related content they have studied before moving on to other content or taking corrective action.

Thus, evaluation activities involves analyzing and interpreting the results and data derived from various measurements in order to make appropriate pedogogical decisions. Whether it is carried out at the beginning of, during, or at the end of one or more learning activities, whether its goal is to provide immediate educational help (formative evaluation) or information on the achievement of a set of objectives (summative evaluation), or whether it involves the use of different types of instruments, it must take into account the related content and the orientations of the program in question.

Thus, whether evaluation is carried out by the teacher, the school, the school board, or the Ministère, it must be consistent with the orientations and the guiding principles of the program. It should also take into account all the thought processes emphasized in the teacher's instructional approach.

Teachers must always be aware of the underlying purpose of any form of evaluation. They may want to ensure that the students have acquired prerequisites, ensure that the teaching plan is appropriate, improve learning and teaching, ensure that the environment is suitable for learning, improve student-teacher interaction, evaluate the degree to which an objective or a set of objectives has been attained, or determine appropriate corrective action.

There are various types of evaluation instruments. The teacher chooses an instrument in accordance with the decision to be made, and interprets the results on a norm-referenced or criterion-referenced basis.

6.1 Need for a "New" Method of Evaluation

One of the key issues in science education today concerns the close relationship between teaching methods and methods of evaluation. Because evaluation procedures have been known to condition teaching, it is important that the new methods of evaluation take into account the related content, the orientations, and the teaching strategies emphasized in the program. It is important to evaluate both the students' approach and their answer to the problem. Evaluation should therefore involve having the student use the scientific method to solve problems. It should also take into consideration the various aspects of learning, namely skills, knowledge, and attitudes.

Students will not benefit from the new approach to physical sciences teaching unless each component of this program is implemented properly. Whether it concerns formative evaluation or summative evaluation, which is mostly the responsibility of the ministère de l'Éducation, the method of evaluating student learning is an essential element of this change.

6.2 Responsibility for Evaluation

Except for the first terminal objective of each module, evaluation for the terminal objectives in both Physical Sciences 416 and Physical Sciences 436 will be carried out by means of a ministry-prepared examination. The evaluation should take into account the orientations underlying the intermediate objectives and the learning activities, and cover for all related content of the program. Additional information on evaluation is provided in the Definition of the Domain for this program. A grade of 60% on this examination is one of the requirements to obtain a Secondary School Diploma.

Evaluation for all enrichment objectives (** and other optional objectives) is the responsibility of the school and/or school board.

7. IMPLEMENTING THE PROGRAM

It has been shown that there is a need for a new approach to the teaching of Physical Sciences. Change will not occur unless all of the following measures are implemented:

- **Professional Development:**
  This program focuses on principles of physics and chemistry. While many teachers have a university degree in one of these disciplines, most have not upgraded their pedagogical skills since the end of the 1960's when a number of teachers were trained to work with American methods such as IPS, PSSC, CHEM STUDY and HPP. In addition, because of the job assignment system, teachers with a background in physics and/or chemistry are often required to teach other subjects, while teachers specialized in other disciplines are forced to teach physics and/or chemistry. This may have affected the quality of instruction.

  It is extremely important to provide the majority of teachers with an opportunity to upgrade their pedagogical skills and, in some cases, their knowledge of the subject they are teaching. Teacher-training should begin as the program is being implemented, while additional knowledge of a particular subject can be acquired through advanced courses offered by certified institutions.

- **Attitudes of Chemistry and Physics Teachers:**
  Despite the fact that these courses could be taken by all students, chemistry and physics education tended to be elitist because the programs were geared to those relatively gifted students who needed prerequisites for more advanced science programs. It is important that these subjects become an integral part of the general education of all students, which does not rule out enrichment activities for students who are more gifted or interested in science.

- **Support Staff:**
  Over one-third of the objectives of the program cannot be attained other than through laboratory activities. Many laboratory experiments require special and careful preparation. Some activities, which involve the handling of chemicals or devices like a bunsen burner, may pose a danger to the students' health and safety. It is important that teachers be assisted by qualified technicians who can help students use laboratory materials properly.

- **Attitudes of School Administrators:**

  Since sciences should be an essential part of every student's general education, administrators must ensure that this program is implemented in accordance with the orientations outlined in this document.

  Administrators should also ensure that all lower-level science progams are implemented in accordance with the spirit of these programs. In this way, students will have already been introduced to an approach with which they will become more familiar in this course.

- **Pedagogical Support:**

  Teaching methods in physical sciences programs (e.g. physics and chemistry) must change profoundly if these subjects are to stimulate the students' interest and prepare them for life and further studies. In the future, solid pedagogical support will be necessary to ensure that teachers are able to upgrade their professional skills.

- **Student Placement:**

  It is of paramount importance that students be divided into homogenous groups based on their interests, abilities, and future needs. The enriched path (Physical Sciences 436) should normally be designed for students who have passed Mathematics 314, Human Biology 314, and Physical Sciences 214, and who intend to take the Secondary V Physics and Chemistry courses in preparation for the college-level Natural Sciences concentration or for certain technical programs. This should account for no more than 40% of the students. The regular path (Physical Sciences 416) is designed for all students. It is assumed that CEGEPS will continue to set realistic chemistry and physics requirements.

- **Organizing Class Time:**

  By providing students with regular class periods of sufficient duration, it will be easier to implement learning situations that will help them achieve the course objectives in a manner consistent with the orientations emphasized in this program.

- **Evaluation of Student Learning:**

  Whether it is conducted at the local level or by the Ministère, evaluation for the objectives of the program should take into account the orientations emphasized in this document.

- **Attitude of Parents and Students:**

  In this world of science and technology, those with a sound scientific background are equipped to meet present and future challenges. Parents should take an interest in their children's education and, if necessary, provide them with the materials they need.

- **Availability of Laboratories (or Teaching Labs):**
  Since one of the goals of this program is to become familiar with scientific work methods, students should have access to laboratories where they will be able to apply procedures that have been developed for them or that they have developed on their own. Over 30% of the objectives of the program cannot be attained other than through laboratory experiments. Every school must provide the students in this course with an adequate number of laboratories.

  The Ministère has published a guide providing information on the organization of teaching laboratories.

- **Equipment:**
  Laboratories should be equipped with hot and cold water, electricity, and gas, and with enough quality lab materials (e.g. measuring and observational instruments, chemicals). It is also important to provide teachers with funds to cover the cost of perishable materials and/or new equipment. Of course, this material must comply with environmental laws and the standards set by the CSST.

  With the help of the Direction de la formation générale, the Fédération des commissions scolaires catholiques du Québec has published a catalogue of materials and products that can be used for this program. This publication has been made available to school boards and private schools.

- **Educational Materials in General:**
  Teachers and students should have access to appropriate educational materials. It is important to choose textbooks that best reflect the orientations and the related content of the program.

  Since teachers consider it to be the most vital tool in their work, educational material must be consistent with the instructional approach and the learning procedure emphasized in this course. Without adequate educational materials, the educational objectives of the program may remain purely theoretical.

  Students are encouraged to find solutions to problems that interest them by consulting encyclopedias, dictionaries, specialized science books, books on the history of science, and other source materials. They can also find useful information by watching films and using educational software. In so doing, they are learning how to use the scientific method to solve problems, which is one of the major goals of this program.

8. RELATED DOCUMENTS

The following documents, published by the ministère, are intended to help teachers and school administrators implement this program in accordance with the orientations outlined in this document. Other documents may be added to this list at a later date.

Cahier d'équipement, Science physiques 416-436. La Fédération des commissions scolaires catholiques du Québec, 1990.

Québec. Ministère de l'Éducation. Direction des programmes. Direction de la formation générale. **Definition of the Domain, Physical Sciences 056-416, 056-436.** Québec: ministère de l'Éducation, 1989.

Québec. Ministère de l'Éducation. **Guide d'aménagement de classes-laboratoires, Sciences physiques 4^e^ secondaire.** Québec: ministère de l'Éducation, 1990.

Québec. Ministère de l'Éducation. **Guide de manipulation et d'élimination des substances dangereuses dans les établissements scolaires.** Code 73-0016. Québec: ministère de l'Éducation, 1989.

Québec. Ministère de l'Éducation. **Guide de soutien à la mise en oeuvre du programme Sciences physiques 416-436.** Québec: ministère de l'Éducation, 1989.

Québec. Ministère de l'Éducation. Direction générale des programmes. **Health and Safety in the Natural Science Laboratory, Information Document, December 1985, Secondary School.** Code 16-3100A. Québec: ministère de l'Éducation, 1985.

Québec. Ministère de l'Éducation. Direction des ressources didactiques. **Procedure for Evaluating Instructional Materials, Physical Sciences 416-436.** Code 16-4311-46A. Québec: ministère de l'Éducation, 1990.

Québec. Ministère de l'Éducation. Vidéo **"Pourquoi"** N° 1200 S 092. Québec: ministère de l'Éducation.

Québec. Ministère de l'Éducation. Vidéo **"Santé, sécurité, environnement: les substances dangereuses"** N° 3100 October 1989, Québec: ministère de l'Éducation, 1989.

APPENDIX I: LIST OF SKILLS AND ATTITUDES*

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* List of principal skills and attitudes that the student should normally continue to develop if this program were implemented in accordance with the orientations outlined in this document. This classification of skills, attitudes, and related indicators should be regarded as a list of suggestions. Teachers may want to modify it depending on their own preferences or the specific classroom situation.

LIST OF SKILLS AND RELATED INDICATORS

Terminal Skill	Intermediate Skills	Indicators
1- Defining a problem (C)	A- Recognizing a problem (C-1)*	- asking how and why new phenomena occur - formulating a question or a problem clearly - identifying all the variables to be measured - re-examining a question or a problem in the light of new data - examining the way in which one variable influences another - identifying the data that is relevant to the problem
	B- Formulating a hypothesis (predicting) (C-2)	- proposing one or more answers to a question - formulating new hypotheses - proposing an explanation (the how and the why) for a phenomenon or an observation - proposing a model - selecting hypotheses that are consistent with his/her observations - predicting the way in which one variable will influence another
	C- Developing an experimental procedure (C-3, C-4)	- determining the experiments required to test a hypothesis - determining the variables to be kept constant - determining the experimental conditions - identifying any danger to human health and safety - identifying anything that could harm the environment - selecting appropriate materials and measuring instruments
2- Gathering information (B, G)	A- Observing (B-1, B-2, G-1, G-2, G-3)	- using his/her senses - using instruments to supplement his/her observations - taking precautionary measures when observing certain phenomena - following the established procedure - working methodically and keeping the work station clean
	B- Measuring (B-3, B-4, B-5, G-1, G-2)	- identifying sources of error - taking the precision of the instrument into account - using SI units to measure physical quantities - reading a measuring instrument correctly - estimating the absolute error in the measurement of a physical quantity - reading and understanding the scale of a measuring instrument - taking significant digits into account - controlling variables to be kept constant
3- Processing Data (D, E, G)	A- Organizing Data (D-1, D-2, G-2)	- classifying his/her observations according to one or more specified criteria - arranging his/her observations measurements, or data according to specified criteria - using tables to present numerical data - using graphs to present numerical data - proposing a classification system - assembling any apparatus based on a diagram - correcting a diagram after assembling an apparatus

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* The alphanumeric code in parentheses refers to the taxonomy in appendix II

Terminal Skill	Intermediate Skills	Indicators
	B- Interpreting Data (D-3, D-4, D-5, E-1, E-2)	- establishing a relationship between two variables - interpreting a graph - representing a phenomenon using a mathematical equation - applying the correct mathematical operators to the data obtained - selecting observations that are relevant to the research topic - drawing inferences from the data - extrapolating beyond actual observations - interpolating between observations - taking absolute and relative errors into account when making calculations - taking significant digits into account when making calculations - incorporating units of measure into a calculation - checking whether the result is plausible by analyzing the units used to quantify a physical quantity - correcting a diagram
4- Concluding (B, D, E, F)	A- Formulating Generalizations (D-6, B-2, F-1 to F-4)	- formulating a working definition of an object, a substance or a phenomenon - describing an object, a substance, or a phenomenon, using a model - identifying an object, a substance, or a phenomenon based on its definition or description - associating the same explanation with different phenomena - drawing conclusions - formulating generalizations based on sufficient data - formulating a theory - formulating a law - identifying everyday phenomena and technological inventions that can be explained through interpretation a hypothesis, a model, a theory - identifying phenomena associated with a particular law - using a model
	B- Constructing a Model (E-1 to E-6)	- recognizing the need to develop a model - constructing a physical model on paper or using a three-dimensional building set - constructing a mathematical model - writing an equation that represents a transformation - writing a balanced equation that represents a transformation - improving a model - representing an object - assessing a model - describing a model
	C- Communicating (F-4)	- using internationally accepted terminology and symbols - presenting work orally and in writing - communicating using correct language

LIST OF ATTITUDES AND RELATED INDICATORS

1. Fascination with science (H-3, H-4, H-6)	- open (spiritually, intellectually, emotionally, sensoriality) to exploring environmental phenomena - fond of learning and experimenting - interested in pursuing a career in science and technology
2. Intellectual curiosity (H-2, H-3, H-4, H-5, I-4)	- keen on acquiring knowledge - attracted to the unknown - confident in his/her ability to find a rational explanation for various phenomena - fond of research - interested in scientific activities
3. Willingness to clarify problems (H-3)	- inclined to define the scope of a question in order to formulate a more clear and precise description of the problem - inclined to define the scope of a question in order to formulate a description which makes it possible to find a plausible solution based on fact
4. Creative approach (ingenuity) (H-3)	- inclined to formulate hypotheses or problem-solving strategies - capable of drawing a variety of verifiable conclusions based on these hypotheses or problem-solving strategies (characteristic of a self-confident, assertive person who can deal with ambiguity, who likes to take risks, and who is not afraid of relying on intuition)
5. Critical attitude (H-3)	- inclined to question any assertion or proposition - inclined to regard an assertion or proposition as a hypothesis - inclined to organize and conduct experiments to test a hypothesis
6. Objectivity (H-3)	- inclined to consider only known or verifiable data - inclined to dismiss subjective data and preconceptions
7. Willingness to interpret information (H-3)	- inclined to look for a logical line of reasoning, trends, or important characteristics when faced with raw data or seemingly unconnected pieces of information - inclined to look for the significance of a body of information - inclined to analyze information
8. Willingness to compare ideas (H-3)	- inclined to compare his/her work with that of others and with reality in order to assess its merit - inclined to accept suggestions that could improve the quality of his/her work
9. Willingness to synthesize and apply knowledge (H-3, F-1, F-2, F-3, I-1, I-4)	- inclined to assess what he/she has learned in order to understand how it relates to other topics - inclined to apply what he/she has learned to other relevant situations

10. Concern for the use of correct language (F-4)	- concerned about using the proper word or expression - always concerned about the meaning of the words or symbols used by other people - concerned with communicating clearly and concisely
11. "Constructivist" view of science (H-1, H-2, I-1, I-2, I-3, I-4, I-5)	- Inclined to regard knowledge as the product of intellectual activity, something that must be constructed - Inclined to regard truth as relative and often subject to change - Inclined to regard scientists as fallible human beings who conduct research - Inclined to regard the scientific method as a way of thinking - Inclined to regard scientific knowledge as a system that is constantly evolving - Inclined to regard science as a product of history - Inclined to consider the social dimension of science
12. Sense of responsibility (concern for health and and safety and the environment) (G-3, I-4, I-5, F-3, H-3, H-4)	- Inclined to keep in the best possible physical condition because it benefits both the individual and society - Inclined to take precautionary measures when doing laboratory or field work - Inclined to act in an environmentally conscious manner - Inclined to recognize the social consequences of scientific and technological development
13. Sense of belonging (H-3)	- aware that he/she is a member of a community - Inclined to act for the good of the community
14. Self-confidence (H-3)	- Inclined to express his/her opinions confidently - Inclined to discuss issues confidently - Inclined to defend his/her opinions
15. Conscientiousness (H-3)	- concerned about producing quality work - perseverant - organized - disciplined

APPENDIX II: TAXONOMY* FOR NATURAL SCIENCES EDUCATION

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* This taxonomy is based on the [illegible] developed by Bloom, Hastings, and Madaus (1971) and on L. E. Klopfer's taxonomy (1971). Some addit[illegible]ve made by the authors of this program.

A- Knowledge and Comprehension

A-1 KNOWLEDGE OF SPECIFIC FACTS
A-2 KNOWLEDGE OF TERMINOLOGY
A-3 KNOWLEDGE OF CONCEPTS OF SCIENCE
A-4 KNOWLEDGE OF CONVENTIONS
A-5 KNOWLEDGE OF TRENDS AND SEQUENCES
A-6 KNOWLEDGE OF CLASSIFICATION, CATEGORIES AND CRITERIA
A-7 KNOWLEDGE OF PROCEDURES AND TECHNIQUES
A-8 KNOWLEDGE OF PRINCIPLES AND LAWS
A-9 KNOWLEDGE OF THEORIES OR MAJOR CONCEPTUAL SCHEMES
A-10 IDENTIFYING KNOWLEDGE IN A NEW CONTEXT
A-11 TRANSLATING KNOWLEDGE FROM ONE SYMBOLIC FORM TO ANOTHER

B- Observing and Measuring

B-1 OBSERVING OBJECTS AND PHENOMENA
B-2 DESCRIBING OBSERVATIONS
B-3 MEASURING OBJECTS AND CHANGES
B-4 SELECTING APPROPRIATE INSTRUMENTS
B-5 ESTIMATING MEASUREMENTS AND RECOGNIZING LIMITS IN ACCURACY

C- Defining a Problem

C-1 RECOGNIZING A PROBLEM
C-2 FORMULATING A HYPOTHESIS
C-3 SELECTING A TEST OF A HYPOTHESIS
C-4 DESIGNING PROCEDURES FOR PERFORMING EXPERIMENTS

D- Interpreting Data and Formulating Generalizations

D-1 PROCESSING DATA
D-2 PRESENTING DATA IN THE FORM OF FUNCTIONAL RELATIONSHIPS
D-3 INTERPRETING DATA
D-4 EXTRAPOLATING AND INTERPOLATING
D-5 TESTING A HYPOTHESIS
D-6 FORMULATING GENERALIZATIONS

E- Constructing a Model

E-1 RECOGNIZING NEED FOR A THEORETICAL MODEL
E-2 FORMULATING A THEORETICAL MODEL
E-3 SPECIFYING RELATIONSHIPS SATISFIED BY A MODEL
E-4 DEDUCING NEW HYPOTHESES
E-5 EVALUATING A MODEL
E-6 FORMULATING A REVISED OR REFINED MODEL

F- Applying Knowledge and Methods

F-1 APPLYING KNOWLEDGE AND METHODS TO NEW PROBLEMS IN THE SAME FIELD OF SCIENCE
F-2 APPLYING KNOWLEDGE AND METHODS TO NEW PROBLEMS IN A DIFFERENT FIELD OF SCIENCE
F-3 APPLYING KNOWLEDGE AND METHODS TO PROBLEMS OUTSIDE OF SCIENCE AND TECHNOLOGY
F-4 USING THE WRITTEN AND SPOKEN LANGUAGE SPECIFIC TO A DISCIPLINE

G- Manual Skills

G-1 DEVELOPING SKILLS IN USING EQUIPMENT NORMALLY USED IN LABORATORY OR FIELD WORK
G-2 DOING LABORATORY OR FIELD WORK METHODICALLY
G-3 DOING LABORATORY OR FIELD WORK CAREFULLY AND SAFELY

H- Attitudes and Interests

H-1 MANIFESTING OBJECTIVE ATTITUDES TOWARDS SCIENCE AND SCIENTISTS
H-2 ACCEPTING SCIENTIFIC INQUIRY AS A WAY OF THOUGHT
H-3 ADOPTING "SCIENTIFIC ATTITUDES"
H-4 ENJOYING SCIENCE LEARNING EXPERIENCES
H-5 DEVELOPING INTERESTS IN SCIENCE AND SCIENCE-RELATED ACTIVITIES
H-6 DEVELOPING AN INTEREST IN PURSUING A CAREER IN SCIENCE OR TECHNOLOGY

I- Epistemological Orientations

I-1 RECOGNIZING RELATIONSHIPS AMONG VARIOUS TYPES OF STATEMENTS IN SCIENCE
I-2 RECOGNIZING THE INFLUENCE AND LIMITATIONS OF SCIENTIFIC INQUIRY
I-3 HISTORICAL PERSPECTIVE: RECOGNIZING THE BACKGROUND OF SCIENCE
I-4 UNDERSTANDING THE RELATIONSHIPS AMONG SCIENCE, TECHNOLOGY, AND SOCIETY
I-5 BECOMING AWARE OF THE SOCIAL AND MORAL IMPLICATIONS OF SCIENTIFIC INQUIRY AND ITS RESULTS

APPENDIX III: PARTIAL LIST OF PUBLISHERS AND AUTHORS[1]

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[1] This list was drawn up on the basis of an earlier version of this program. An update to include all the references that appear in the final version would have entailed delaying the publication of the English version. The ministère de l'Éducation regrets this inconvenience.

Publisher	Title	Author
Academic Press Canada 55 Barber Green Road Don Mills, Ont. M3C 2A1	The Ideas of Physics	Giancoli
The American Chemical Society 1155 16th N.W. Washington, D.C.	Chemical Matters	
Bantam Science and Math 271 Madison Ave. New York, N.Y., 10016	The Atoms and Beyond	Smith
	16mm Films:	
Britannica Learning Materials P.O. Box 2249, Britannica Place Cambridge, Ont. N3C 2N4	Learning about Electric	
	Learning about Magnetism	
	What is Electric Current?	
Cebeco Standard Publishing 9 Kulick Road Fairfield, New Jersey, 07006	Chemistry: The Study of matter	Dorin
Chemical Institute of Canada Ottawa, Ont.	Laboratory Safety handbook	Ordre des Chimistes du Québec
Chem 13 News Dept. of Chemistry University of Waterloo Waterloo, Ont. N2L 3G1	Acid-Base Magic Wand	

COMPress Educational Software Wenworth, New Hampshire, USA 03282	Chemistry: Chemical Formulas and Equations	
	Chemistry: Lewis Diagrams	
	Chemistry: Solutions	
Copp Clark Pitman Ltd. 2775 Mathseson Blvd. East Mississauga, Ont. L4W 4P7	Insights 9	Jolliffe, Goring, Jones, Killam
	Insights 10	Jolliffe, Jones, Killam, Lyons
	Chemistry at Work	Shapiro and Shapiro
	Videos:	
Coronet 3771 Victoria Park Scarborough, Ont. M1W 2P9	Introducing Chemistry	
	Solutions	
	Brochures:	
Environment Québec 5199 boul. René Lévesque Montréal, Qué.	Les précipitations acides et l'environnement	
	Quand la pluie chasse les grenouilles	
Hachette International Québec Livres 4435 des Grandes Prairies St. Léonard, Qué H1R 1A5	Dictionnaire de physique	Sarment

Holt, Rinehart and Winston of Canada Limited Toronto, Ont.	Foundations of Chemistry	Toon, Ellis, Brodkin
	Chemicals in Action	Donovan, Poole, Tack
	Modern Chemistry	Metcalfe, Williams, Castka
	ctricity	Paul, Peirce, Steit
	Videos:	
Hydro-Québec 201 Jarry St. West Montréal, Québec H2P 1S7	At 735 Kv, Liveline Work	
	Challenge Mat (A)	
	Electrotechnologies and Industry: Resistance Heating La facture d'Hydro-Québec High Performance Crossing Synchronous Condensers	
	16mm Film:	
International Tele-Film 4480 Côte de Liesse, suite 370 Ville Mont-Royal, Qué. H4N 2R1	Molecules – A First Film	
Irwin Publishing Inc. 180 West Beaver Creek Rd. Richmond Hill Ont. L4B 1B4	Matter and Energy	Spencer, McNeill, MacLachlan
Kendall/Hunt Publishing Co. 2460 Kerper Blvd. P.O. Box 539 Dubuque, Iowa, 52001	Chemistry in the Community, The Chemical Industry: Promise and Challenge	The American Chemical Society

McClelland & Stewart Inc. 481 University Ave. Toronto, Ont. M5G 2E9	The Canadian Green Consumer Guide: How Can We Help?	
McGraw-Hill Ryerson Ltd. P.O. Box 400 Hightstown N.J., 08520	Exploring Chemistry	Ord
	Handbook of Chemistry	
Meridian Press 1980 Sherbrooke St. West Montréal, Qué. H3H 1E8	Our Energy Heritage	Carpentier
	Videos:	
Multimédia Audiovisuel Inc. 5225 Berri Montréal, Qué. H2J 2S4	Les appareils de mesure Le magnétisme Les conducteurs électriques Le circuit électrique Les montages électriques Le circuit série Le circuit parallèle Le circuit mixte	

National Film Board - N.F.B. Complexe Guy Favreau 200 boul. René Lévesque W. Montréal, Qué. H2Z 1X4	**Videos:** Acid Rain from Heaven Acid Rain: Requiem or Recovery Air A Matter of Attitudes A Time for Action Atomic Energy Canada Electricité d'origine nucléaire Gens d'Abitibi Isotopes in Action La pollution venue du ciel le vent domestique Nuclear Power Demonstration Le Combat d'Onésime Tremblay Paradise Lost Petroleum's Progress Perspectives in Science (series of 4 titles) Power in Perpetuity The Underlying Threat **Films:** Thomson's Atomic Model Water Water, Water Everywhere	
Prentice Hall of Canada 1870 Birchmount Road Scarborough, Ont. M1P 2J7	A Guide to the Study of Environmental Pollution	Andrews
Radio-Canada 1400 Boul. René Lévesque E. Montréal, Qué. H2L 2M2	**Video:** L'Hydro électricité	

Québec School Television Radio-Québec 600 Fullum St. 5th floor Montréal, Qué. H2K 3L6	**Videos:** About Science (series of 37 titles) Concepts in Science (series of 9 sixty-minute tapes) Eureka (series of 30 titles) What About (series of 12 titles) Acid Rain J'aime les éléments	
Science Supplies and Services Idea Bank Collation A Handbook for Science Teachers Queen's University Kingston, Ont. K7L 3N6	Chemistry Magic Foaming Colors Periodic Table of Elements Rutherford Atom	Gordon Perkins Favero Hindin
SPECTRE Association des professeurs de sciences du Québec 10,654 Jeanne-Mance Montréal, Qué.	Industrie Chimique Québécoise	Cliche
Ward's Natural Science Establishment 1840 Walfare Ave. Mississauga, Ont. L4X 1G1	**Films:** Acid-Base Indicators Chemical Families Electrical Potential Energy Part I Electrical Potential Energy Part II **Video:** Electric Interaction in Chemistry	

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